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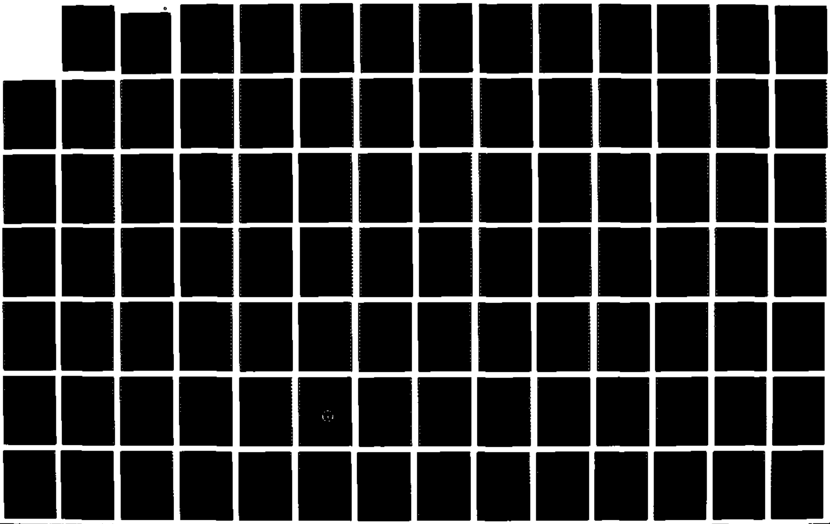

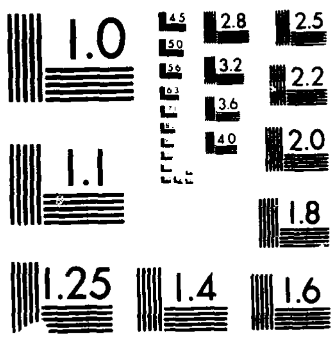
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Technical Document 552
March 1989

KAPSE Interface Team Public Report

Volume VI

D.L. Hayward

Prepared for Ada Joint Program Office

NAVAL OCEAN SYSTEMS CENTER

San Diego, California 92152-5000

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Technical Director

ADMINISTRATIVE INFORMATION

This report was compiled by the Computer Software and Technology Branch (Code 411) of Naval Ocean Systems Center for the Ada Joint Program Office. This report is the sixth in a series and represents evolving ideas and progress of the KAPSE Interface Team (KIT).

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CONTENTS

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Section 1

INTRODUCTION

INTRODUCTION

This report is the sixth in a series that is being published by the KAPSE Interface Teram (KIT). The previous reports are as follows:

Vol. #	NOSC Report #	Date	NTIS Order #
I	TD-209	4/82	AD A115 590
II	TD-552	10/82	AD A123 136
III	TD-552	10/83	AD A141 576
IV	TD-552	4/84	AD A147 648
V	TD-552	8/85	AD A160 355

This series of reports serves to record the activities to date and to submit for public review the products that have resulted. The reports are issued to cover approximate six-month periods. The reports should be viewed as snapshots of the progress of the KIT and the companion team, the KAPSE Interface Team from Industry and Academia (KITIA); everything ready for public review is included. These reports represent evolving ideas, so the contents should not be taken as fixed or final.

MEETINGS

During this reporting period (November 1984 through April 1985) the teams met in January 1985 in San Diego, CA, and in April 1985 in Washington, DC. However, due to a gap in contractual support, there are no minutes for those two meetings. This report does include, however, the minutes of one working group's activities (COMPWG) during the January meeting. This report also includes the management plan for 1985.

COMMON APSE INTERFACE SET (CAIS)

The delivery of the Proposed MIL-STD-CAIS (known as CAIS-1) was made on time to the Ada Joint Program Office (AJPO). CAIS-1 is a significant milestone in the life of the KIT and KITIA, one long awaited. Only the initial few pages of this document are included in this report. The full text can be obtained from National Technical Information Service (NTIS) by using order number AD A157 589.

This draft takes into account all of the comments received at the two additional public review meetings held in August and November of 1984. The input from the participants is quite valuable. The feedback received from the August meeting regarding the incorporation of security in the CAIS is helpful. I would like to take this opportunity to again thank all those who attended.

This draft is preceded by a cover letter from Dr. Robert Mathis, director of the AJPO at the time the report was delivered. Dr. Mathis states, there has been a lot of concern in the community, once a standard is issued, the standard could well be misapplied. The intent is to gain concurrence regarding the policy of application this letter proposes. If sufficient support for such a statement is acquired during the standard review process, words to the effect of those in this letter will be incorporated into the final standard. Therefore, feedback on this aspect is welcome.

Competitive procurement of a contractor for CAIS Version 2 is proceeding and is still scheduled to take place during 1985.

STANDARDS

Even though the old Standards Working Group (STANDWG) was folded into the Compliance Working Group (COMPWG), the members continue to provide reviews of standards that may be of interest. Another such report is included in this volume.

I&T TOOLS

Products are now emerging from the effort to implement the APSE Interactive Monitor (AIM). The first report included here is one by Stewart French discussing "A Virtual Terminal Specification and Rationale."

PROTOTYPING

A number of what were previously background issues have started to emerge, now that the first version of the CAIS has been delivered. One of these issues is prototyping and the role prototyping plays in verifying the ideas in the CAIS. Because a number of groups are starting to pursue prototyping activities, we must provide some guidelines for such prototyping and what the KIT/KITIA could and should expect to receive from such activities. These thoughts and discussions led to the paper included here by P. Oberndorf, "Prototyping the Common APSE Interface Set (CAIS)." This letter led to the start of a prototyping effort by TRW, under contract to NOSC. This effort is represented by briefing slides from the January 1985 meeting. This briefing discussed a variety of goals in developing a CAIS prototype and their effect on some of the design issues.

The April 1985 meeting also was provided with a briefing about the CAIS prototype being developed independently by MITRE.

KIT/KITIA PAPERS

One KITIA paper in included in this report. The paper deals with some questions regarding standardization.

CONCLUSION

This Public Report is provided by the KIT and KITIA to solicit comments and feedback from those who do not regularly participate on either of the teams. Comments on this and all previous reports are encouraged. They should be addressed to

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or sent via ARPANET/MILNET to **HAYWARD@NOSC-TECR.ARPA.**

Section 2

TEAM PROCEEDINGS

MINUTES
KITIA
COMPLIANCE WORKING GROUP
JANUARY 14-18, 1985
CATAMARAN
SAN DIEGO, CA.

B. Abrams was elected chairman.

The Compliance Working Group (COMPWG) is concerned with establishing guidelines for measuring compliance of

CAIS Standard to CAIS Requirements and Criterion Document
CAIS Implementation to CAIS Standard.

The major areas to be worked on between now and the next meeting are

1. Issues on the validation test suite (V. Castor)

2. Guidelines for Subsets of a CAIS (T. Lindquist, R. Drake)

3. Semantics - Guidelines for specifying the semantics of the CAIS so that it can be measured. (R. Freedman, B. Abrams)

4. Standards - Comparison of CAIS to other Standards (W. Loper)

5. CAIS Standard compliance with CAIS Requirements. (J. Foidl)

White papers will be prepared prior to the next KIT/KITIA meeting. The group chairman will present a summary of the papers at that meeting.

The following is a summary of the discussion on the above issues. In validation the emphasis will be technical rather than administrative. What is validated must be decided. It could be a CAIS on a given host computer - operating system combination.

Evaluation is separate from validation. Validation is concerned with the CAIS implementation meeting the syntax and semantics of the CAIS standard. It is objective and binary. Evaluation is concerned with performance and useability. It is subjective. Some members were of the opinion that we should not consider evaluation.

The question of whether or not there should be subsets was discussed. It was decided to consider the implications of subsets first since this may shed light on the previous question. If there are subsets they should not be arbitrary. Some ways of defining subsets are:

Functional
Layered
Project Oriented
Device Dependent
Implementation Convenience

....

B. Abrams

Section 3

KIT/KITIA DOCUMENTATION

Ada Programming Support Environment

(APSE)

Interoperability and Transportability (I&T)

Management Plan

January 1985

for

Ada JOINT PROGRAM OFFICE
The Pentagon
Washington, D.C. 20301

prepared by

NAVAL OCEAN SYSTEMS CENTER
271 Catalina Boulevard
San Diego, California 92152

1.0 INTRODUCTION

The Ada Programming Support Environment (APSE) Interoperability and Transportability (I&T) Plan is presented in this document. The I&T activities necessary to achieve sharing of tools and data bases between APSEs are described. Schedules and milestones for these activities are presented as well as a Work Breakdown Structure (WBS) for accomplishing them.

These I&T activities are conducted by the Kernel APSE Interface Team (KIT).

The major responsibilities are:

a. APSE I&T Management
b. APSE I&T Analysis
c. APSE I&T Standards Development
d. APSE I&T Tools Development
e. APSE I&T Coordination with Implementation Efforts

1.1 BACKGROUND

In 1975 the High Order Language Working Group (HOLWG) was formed under the auspices of the U.S. Department of Defense (DoD) with the goal of establishing a single high order language for new DoD Embedded Computer Systems (ECS). The technical requirements for the common language were finalized in the Steelman report [1] of June 1978. International competition was used to select the new common language design. In 1979 the DoD selected the design developed by Jean Ichbiah and his colleagues at CII-Honeywell Bull. The language was named Ada in honor of Augusta Ada Byron (1816-1851), the daughter of Lord Byron and the first computer programmer.

It was realized early in the development process that acceptance of a common language and the benefits derived from a common language could be increased substantially by the development of an integrated system of software development and maintenance tools. The requirements for such an Ada programming environment were stated in the STONEMAN document [2]. The STONEMAN paints a broad picture of the needs and identifies the relationships of the parts of an integrated APSE. STONEMAN identifies the APSE as support for "the development and maintenance of Ada application software throughout its life cycle". The APSE is to provide a well-coordinated set of tools with uniform interfaces to support a programming project throughout its life cycle. The Initial Operational Capabilities (IOCs) are called Minimal Ada Programming Support Environments (MAPSEs).

[1] Requirements For High Order Computer Programming Languages: STEELMAN, DoD, June 1978

[2] Requirements for Ada Programming Support Environments, STONEMAN, DoD, February 1980

The Army and Air Force began separate developments of APSEs. The Army APSE has been designated the ALS (Ada Language System) and that of the Air Force, the AIE (Ada Integrated Environment). The Navy APSE will make maximum use of those Army and Air Force products that meet Navy requirements and will require the development of only those additional components required for Navy applications.

The Ada Joint Program Office (AJPO) was formed in December 1980. The AJPO coordinates all Ada efforts within DoD to ensure their compatibility with the requirements of other Services and DoD agencies, to avoid duplicative efforts, and to maximize sharing of resources. The AJPO is the principal DoD agent for development, support and distribution of Ada tools and Ada common libraries.

1.2 DEFINITIONS

INTEROPERABILITY: Interoperability is the ability of APSEs to exchange data base objects and their relationships in forms usable by tools and user programs without conversion. Interoperability is measured in the degree to which this exchange can be accomplished without conversion.

TRANSPORTABILITY: Transportability of an APSE tool is the ability of the tool to be installed on a different KAPSE; the tool must perform with the same functionality in both APSEs. Transportability is measured in the degree to which this installation can be accomplished without reprogramming. Portability and transferability are commonly used synonyms.

1.3 OBJECTIVES

The objectives of the APSE I&T effort are:

1. To develop requirements for APSE I&T.

   STONEMAN paints a broad picture of the needs and relationships of the parts of an integrated APSE. Although STONEMAN is being used as the primary requirements document for APSE development efforts, it does not provide sufficient detail to assure I&T between APSEs. APSEs built to accomodate I&T requirements will insure cost savings in the development of tools. The cost of reprogramming tools for different APSEs will be significantly reduced.

2. To develop guidelines, conventions and standards to be used to achieve I&T of APSEs.

   Guidelines, conventions, and standards describe the means by which the requirements can be satisfied. It would be premature to develop steadfast standards during the early part of this APSE I&T effort. There is little precedent for I&T between programming support environments of this anticipated magnitude and thus little guidance for the development of these guidelines, conventions, and

standards. The guidelines, conventions and standards that are developed during this APSE I&T effort will evolve over a five year period from 1982 through 1987. These guidelines, conventions, and standards will be presented in public forums to insure that they are sound and realistic.

3. To develop APSE I&T tools to be integrated into both APSEs.

   This APSE I&T effort provides for the development of tools to be integrated into various APSEs. These tool development efforts will help identify interfaces and surface interface problems associated with I&T between different APSEs. They should also show how closely the guidelines, conventions and standards developed by this APSE I&T effort reflect the reality of the various APSE efforts. But the tools developed by this APSE I&T effort will not be limited to this test function. They will also be well-documented tools which will become useful additions to any APSE.

4. To monitor the AIE and ALS development efforts with respect to APSE I&T.

   This APSE I&T effort provides for the monitoring of the AIE and ALS development efforts. The monitoring will result in recommendations for resolution of differences between the AIE or the ALS and the evolving APSE I&T conventions and standards. Interface areas which would inhibit I&T between the AIE and ALS will also be identified.

5. To provide initiative and give a focal point with respect to APSE I&T.

   A focal point is needed for APSE developers and users with regard to information about I&T. APSE I&T questions arise frequently within professional societies and user groups. A forum is needed in which APSE I&T questions can be addressed and discussed and in which APSE I&T information can be disseminated throughout the Ada community.

   The KIT and KITIA (see Sections 2.3 and 2.4) will provide focal points for the Ada community. Public reports on the results of this APSE I&T effort will be published every six months. This is in keeping with the AJPO philosophy of public exposure of all aspects of the Ada program. The KIT and KITIA will also participate in other programs connected with APSE I&T, including international development efforts, whenever possible.

6. To develop and implement procedures to determine compliance of APSE developments with APSE I&T requirements, guidelines, conventions and standards.

   Procedures must be established by which the recommendations that are developed by this APSE I&T effort will be reviewed and implemented by the AJPO. The procedures that are to be followed should apply not only to the AIE and ALS development efforts, but

also to other APSE development efforts. Work on the determination of compliance procedures will be pursued in cooperation with the AJPO's Evaluation and Validation program.

1.4 DOCUMENT ORGANIZATION

Section 1 of this document discusses the purpose and scope of the I&T Plan, the objectives of the I&T effort, and the basic concepts, definitions, and objectives.

Section 2 discusses the sponsorship, the participating organizations, the organizational inter-relationships and responsibilities, and the potential forums for public involvement.

The specific tasks to be accomplished in pursuit of I&T are covered in Section 3. These functions are presented in a work breakdown structure for the project and a schedule of milestones and deliverables.

Special needs in achieving I&T are discussed in Section 4, and a list of references is given in Section 5.

Appendix A contains a glossary of terms and acronyms applicable to the I&T effort. Appendix B describes the elements of the I&T Work Breakdown Structure.

2.0 ORGANIZATION

Figure 1 shows the participants in the APSE I&T effort. The following sections provide a brief description of these organizations and their relationships.

2.1 Ada JOINT PROGRAM OFFICE

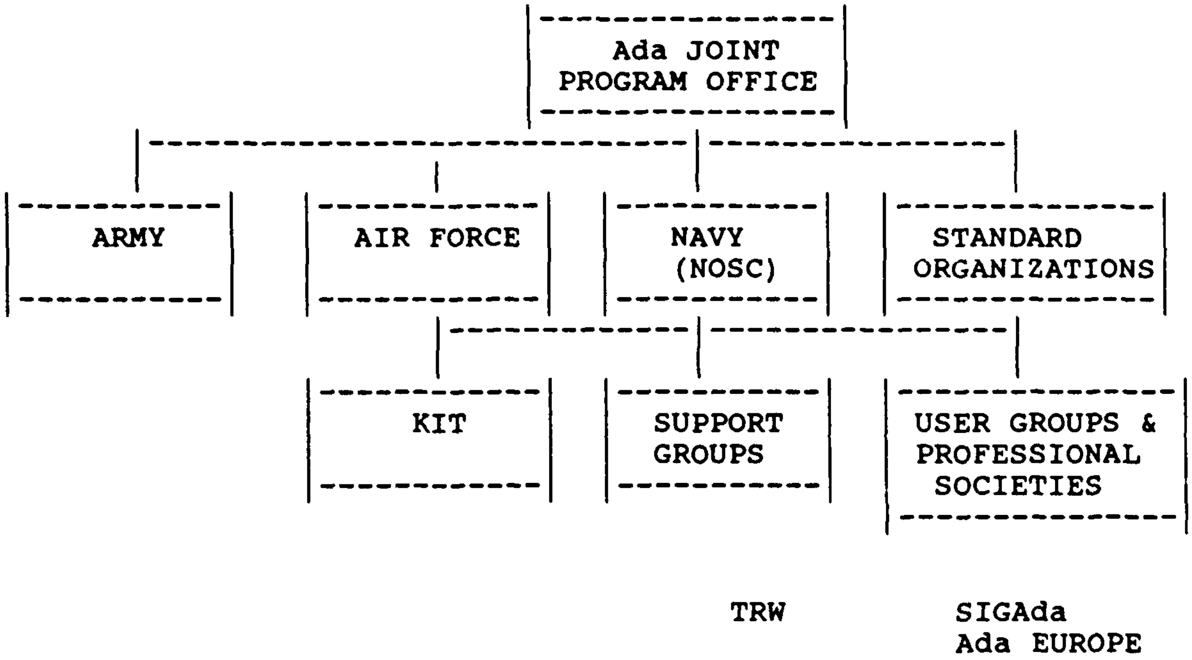
The KIT is an agent of the Ada Joint Program Office (AJPO). The KIT supports the AJPO by performing the activities outlined in this plan and by providing recommendations and information to the AJPO. The AJPO makes final decisions in the areas of requirements, policy, procedures and funding.

The Software Technololgy for Adaptable Reliable Systems (STARS) Joint Program Office (SJPO) was formed after the initiation of the KIT effort. It has come to take an increasing responsibility for efforts involving software engineering environments (SEEs). Since the KIT work is closely related to such efforts, it is anticipated that sponsorship of the KIT work will move from the AJPO to the SJPO in the future. In the mean time, the STARS SEE projects and the KIT/KITIA have some co-members and share and review one another's documents.

2.2 ARMY, AIR FORCE AND NAVY

Currently the Army and Air Force have begun separate developments of APSEs. In the development of its APSE, the Navy plans to make maximum use of Army/Air Force products that meet Navy requirements. The KIT will review of all these APSE developments and identify critical aspects of the designs where conventions or standard interfaces and specifications are needed to insure compatibility. It will be the role of the KIT to interact with these services and their respective APSE contractors for information-exchange and consultation. The contractor for the Army's ALS is SofTech Inc.; the Air Force contractor for the AIE is Intermetrics Inc.. The Navy contractor has not been selected yet. Representatives of both the Air Force and Army APSE development efforts are members of the KIT, and many members of the Navy's Design Review Group (DRG) serve on the KIT as well.

Figure 1. APSE I&T Participants



2.3 KAPSE INTERFACE TEAM (KIT)

The objectives of the KIT are the objectives of the APSE I&T effort (see Section 1.3). The Navy is responsibile for chairing the KIT. The membership is composed of the following DoD representatives:

- Navy Deputy to the Ada Joint Program Office
- Naval Ocean Systems Center (NOSC)
- Naval Sea Systems Command (NAVSEA/PMS-408)
- Naval Electronics Systems Command (NAVELEX)
- Naval Underwater Systems Center (NUSC)
- Naval Surface Weapons Center (NSWC)
- Naval Avionics Center (NAC)
- Naval Air Development Center (NADC)
- Naval Research Laboratory (NRL)
- Naval Weapons Center (NWC)
- Fleet Combat Direction System Support Activity (FCDSSA) - Dam Neck
- Fleet Combat Direction System Support Activity (FCDSSA) - San Diego
- U.S. Air Force - Rome Air Development Center (RADC)
- U.S. Air Force - Air Force Wright Aeronautical Laboratories (AFWAL)
- U.S. Army - Communications and Electronics Command
- Johns Hopkins University Applied Physics Laboratory (JHUAPL)
- National Security Agency
- Canadian National Defense Headquarters

NOSC is the Navy laboratory which has assumed the responsibility of the KIT chairman. All other members participate on a volunteer basis, aided as necessary by the AJPO with funding for such things as travel expenses. New members will be added to the KIT at the discretion of the AJPO.

Because of the potentially large membership of the KIT, a management steering committee called the KIT Executive Committee (KITEC) has been established. It consists of the AJPO sponsor (i.e., the AJPO Navy deputy), the KIT chairman, the primary support contractor (see Section 2.5), and selected other KIT members as determined by the sponsor and chairman. The KITEC is responsible for the planning and management of the APSE I&T effort, including maintenance of this plan and direction of activities in accordance with its tasks and schedules.

In addition, the KIT is divided into various working groups for the purpose of small group concentration on specific technical areas affecting I&T. The number, activities, and membership of such working groups may change as KIT needs change. Currently, the following working groups are active:

- o Common APSE Interface Set Working Group (CAISWG) - The objective of this working group has been to design the initial set of KAPSE-level interfaces. They are also responsible for fielding and answering the comments submitted by reviewers of the designed set. Upon award of the contract for the subsequent version (CAIS Version 2), the CAISWG will have primary responsibility for technical evaluation of the contractor's products.

- o Requirements and Design Critieria Working Group (RACWG) - The objective of this working group is to define and refine the requirements to which CAIS Version 2 is to be designed.

- o Guidelines and Conventions Working Group (GACWG) - The objective of this working group is to define the various guidelines for writing transportable software, in addition to the use of the CAIS.

- o STONEMAN Working Group (STONEWG) - The objective of this working group is to refine the current STONEMAN document to make it more useful and usable as a guiding document for all KIT activities.

- o Compliance Working Group (COMPWG) - The obkective of this working group is to consider the CAIS and other KIT products from the standpoint of determination of implementation conformance.

- o Definitions Working Group (DEFWG) - The objective of this working group is to maintain consistency in the use of terms in all KIT documents and related activities.

2.4 KAPSE INTERFACE TEAM FROM INDUSTRY AND ACADEMIA

The KITIA was formed to complement the KIT and to generally contribute a non-DoD perspective to the I&T effort. The KITIA supplements the activities of the KIT. It assures broad inputs from software experts and eventual users of APSE's. The KITIA interacts with the KIT as reviewers, as proposers of APSE I&T requirements, guidelines, conventions and standards, and as consultants concerning implementation implications. The team was selected from applicants representing industry and academia. The following are the members of the KITIA:

Alpha-Omega Group
Aerospace Corporation
Bell Laboratories
Boeing Aerospace
Computer Sciences Corporation
Control Data Corporation
Commission of the Europen Communities
Ford Aerospace
Frey Federal Systems
General Electric
General Telephone & Electronics Laboratories

Georgia Institute of Technology
Grumman Aerospace
Hazeltine
Honeywell
Hughes Aircraft
IABG (W. Germany)
IBM
Litton
Lockheed
McDonnell Douglas
Norden
PRC
Raytheon
SDC
UK Ada Consortium
Virginia Polytechnic Institute

In addition, the following is a special associate member of the team:

Oy Softplan Ab (Finland)

Membership on the team belongs to a company or university and not to an individual representing his/her organization. All participation is voluntary, and the members selected have agreed to provide 1/3 of a man-year plus other support such as travel expenses. The membership of the KITIA will not be expanded unless an organization withdraws or very special circumstances apply. The AJPO sponsor and KIT chairman are ex-officio members of the KITIA.

The KITIA elects a chairman and a vice-chairman from amongst its participants every year. It is organized into groups who in turn select their own chairmen. The KITIA chairman and vice-chairman together with the group chairmen form the KITIA management committee. In addition, the KITIA is divided into the same set of working groups as the KIT (see Section 2.3).

The KITIA is responsible to the AJPO through the KIT chairman. Although the KIT has ultimate responsibility for the development of all products required to meet the I&T objectives, the KITIA participates directly in the generation and review of such products. In addition, the KITIA generates its own contributing papers, products, initiatives, and recommendations to supplement and guide the basic KIT efforts. This requires close coordination, which is facilitated by ARPANET/MILNET communication mechanisms, parallel working group structures, and joint team meetings.

2.5 SUPPORT CONTRACTORS

Currently there are two contractors that participate on the KIT. TRW is the primary support contractor, providing general support and technical initiatives. Texas Instruments is developing an APSE tool in support of the I&T objectives (see Section 1.3 3). A contractor to evolve the initial work of the KIT/KITIA CAIS Working Group will be selected in the spring of 1985 via a competitive award to expand the Common APSE Interface Set for submission as a military standard.

2.6 EVALUATION AND VALIDATION (E&V) TEAM

In keeping with the approach to Ada itself, the AJPO intends to be able to validate conformance of implementations to the CAIS. Criteria for such validation testing of the CAIS is the concern of the COMPWG (see Section 2.3), working closely with the Air Force-lead Evaluation and Validation Team. The Air Force Wright Aeronautical Laboratories is the lead organization of the Evaluation and Validation Team which will develop the technology required for a central agent to perform I&T validation testing on each APSE. The models for a strong central validation capability are the Ada Compiler Validation Capability and the Ada Validation Organization (AVO).

2.7 USER GROUPS AND PROFESSIONAL SOCIETIES

It is anticipated that SIGAda, the Ada-JOVIAL Users Group (Ada-JUG), and Ada Europe will provide valuable contributions to the APSE I&T effort. The KIT and KITIA have no formal relationship with these groups; however, the KITEC will use some or all of these groups as regular forums for the presentation of reports and technical results and will solicit feedback from their members.

2.8 STANDARDS ORGANIZATIONS

The American National Standards Institute (ANSI) and the International Standards Organization (ISO) are standards organizations which are already involved in establishing the Ada programming language as a broadly recognized, enforceable standard. It is possible that the results of this I&T effort will be submitted for such approval by these organizations as well, to effect the commonality of APSE's deemed necessary to achieve DoD's life-cycle objectives. The KIT initially will become familiar with the organizations' standardization procedures so that future standardization actions can be planned and accomplished with minimum difficulty. This will include the study of existing standards which may interact with or guide the development of APSE I&T standards.

2.9 LIAISON WITH IMPLEMENTATION EFFORTS

A number of APSE implementation efforts have been undertaken by organizations outside of the DoD. Three of these (the U.K. Ada Consortium, the West German IABG and U.C. Irvine) have participated on the KITIA. Others include the European Economic Community, ROLM Corporation, Western Digital, and Telesoft, just to name a few. The KIT will keep such organizations informed of its activities and will consider all feedback received from them.

In addition, a number of organizations are currently involved, to varying degrees, in implementations of the first version of the CAIS. These organizations have formed a CAIS Implementor's Group (CIG) which meets during most of the SIGAda meetings. Members of the KIT/KITIA CAISWG participate in the CIG and provide liaison between the groups.

3.0 APSE I&T PLAN

This section shows the Work Breakdown Structure (WBS) for the I&T effort as well as the schedules and milestones for the WBS elements. Figures 2 thru 7 provide an overview for the WBS elements.

3.1 WORK BREAKDOWN STRUCTURE

A discussion of the major elements in the WBS is presented below. Detailed task descriptions are contained in Appendix B.

1000 APSE Interoperability & Transportability Management

This WBS element covers the general management tasks required to accomplish the APSE I&T objectives. It includes general project and team management, project planning, general meeting and team support and configuration management.

2000 APSE Interoperability & Transportability Analysis

This WBS element covers the technical analysis tasks required to accomplish the APSE I&T objectives. It includes resource reviews, requirements development, and performance of special studies.

3000 APSE Interoperability & Transportability Standards

This WBS element describes the standardization tasks required to accomplish the APSE I&T objectives. It includes guidelines and conventions development, specification development, compliance and validation formulation, common APSE interface set analysis, and definition and support of the standardization process.

4000 APSE Interoperability & Transportability Tools

This WBS element describes the development of APSE tools that support the APSE I&T objectives. It includes planning and acquisition of tools, tool development, test and analysis, and maintenance and modification of developed tools.

5000 APSE Coordination with Implementation Efforts

This WBS element describes the tasks affecting various APSE development efforts required to support the APSE I&T objectives. It includes public reviews of the AIE and ALS, development of prototypes of the Common APSE Interface Set, I&T analysis of AIE and ALS, and liaison with other implementations groups.

Figure 2 WBS Overview

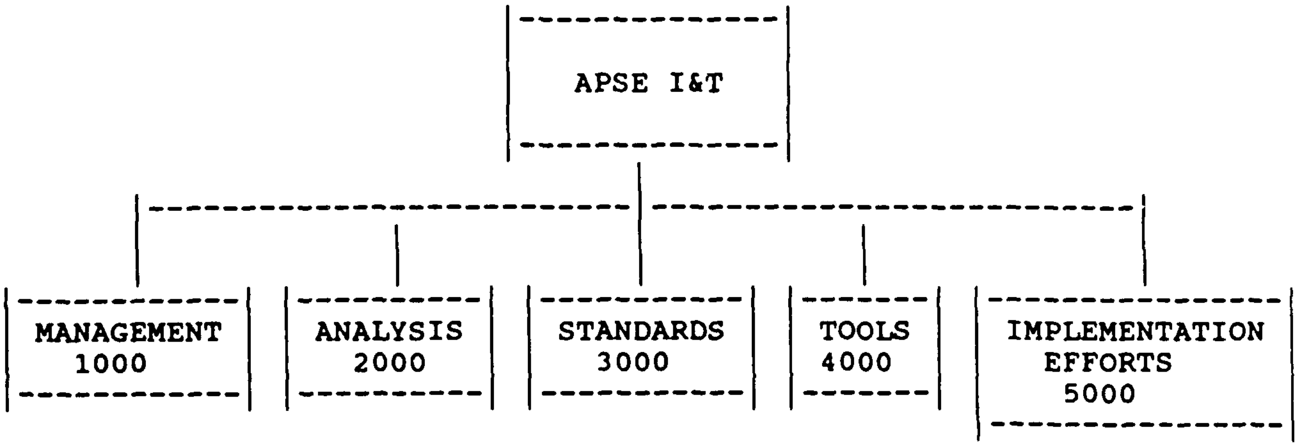


Figure 3 WBS Management Overview

- MANAGEMENT 1000
  - PROJECT MANAGEMENT 1100
    - Team Management 1110
    - Presentations & Briefings 1120
    - Standards 1140
    - Contracts 1150
  - PLANNING 1200
    - Management Plan 1210
    - Funding Allocation 1220
    - Strategy 1230
  - ADMINISTRATIVE SUPPORT 1300
    - Meeting Support 1310
    - Team Support 1320
    - Publications 1330
      REQ/GL/STD
    - Correspondence 1340
  - CONFIGURATION MANAGEMENT 1400

Figure 4 WBS Analysis Overview

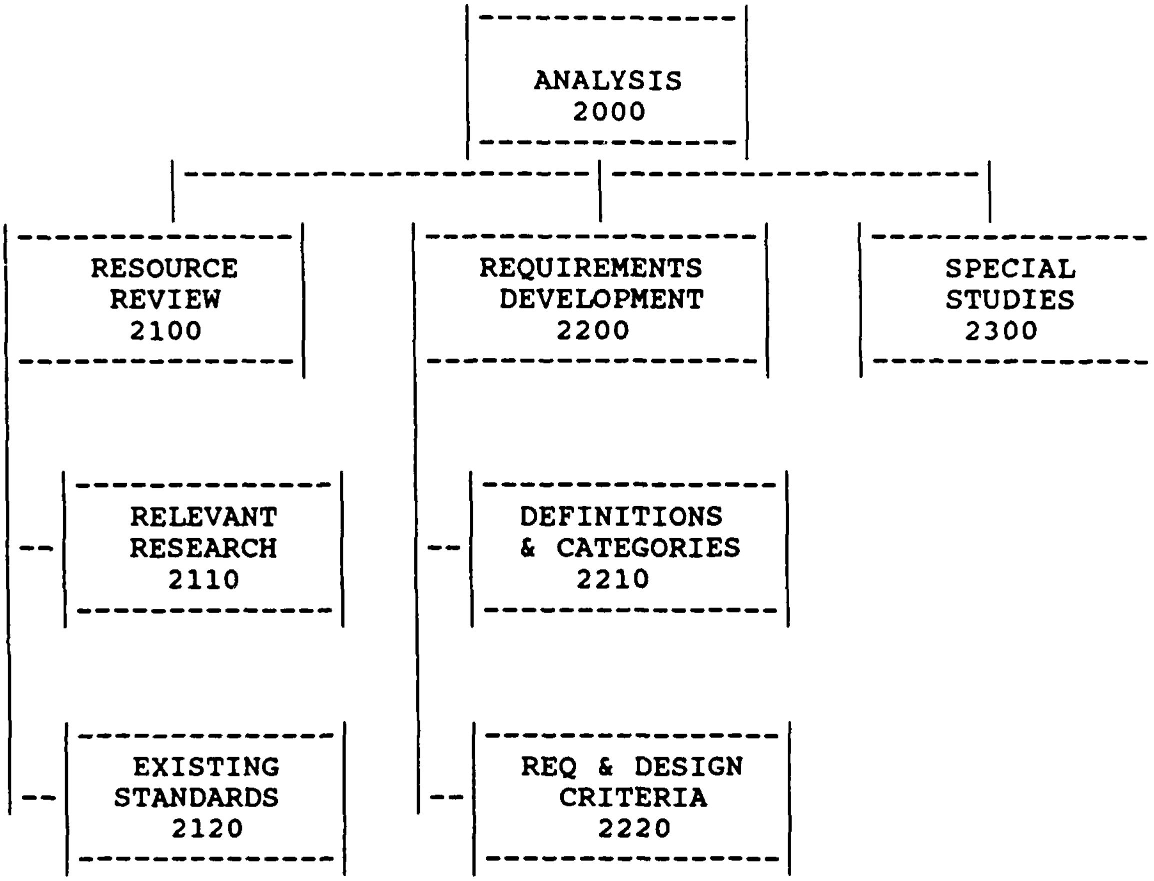


Figure 5 WBS Standards Overview

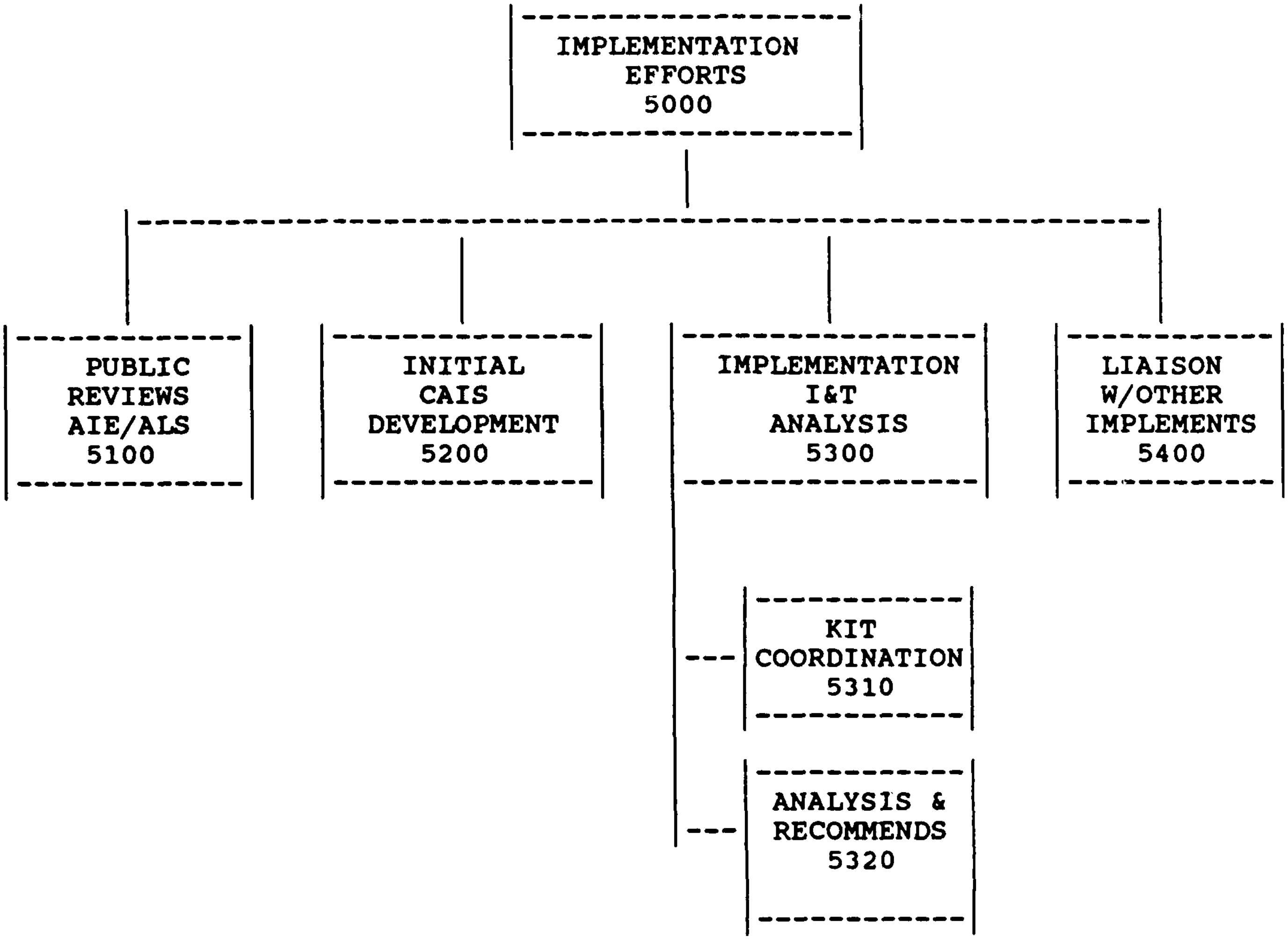
- STANDARDS 3000
  - GL & CONV DEVELOPMENT 3100
  - SPECIFICATION DEVELOPMENT 3200
  - COMPLIANCE 3300
    - COMPLIANCE PROCEDURES 3310
    - VALIDATION RECOMNDTS 3320
  - CAIS ANALYSIS 3400
    - EXPR'MNTL IMPLEMENT 3410
    - PUBLIC REVIEW 3420
  - STANDARDIZATION PROCESS 3500

Figure 6 WBS Tools Overview

TOOLS
4000

- PLANS & ACQUISITIONS 4100
- TOOLS DEVELOPMENT 4200
- TEST & ANALYSIS 4300

Figure 7 WBS Implementation Effort Overview



3.2 MAJOR APSE I&T DELIVERABLES

This section delineates the major deliverables of the APST I&T work.

3.2.1 APSE I&T Plan -

The APSE I&T Plan provides a detailed and organized approach to the accomplishment of the APSE I&T work. The plan reflects the management and technical approaches and the schedules for all activities. The plan is evolutionary and is apdated annually to reflect changes in approach or schedule and to reflect accomplishments.

3.2.2 KIT Public Reports -

The KIT Public Reports are published every six months. Each one reflects the work that has been accomplished since the previous report, including deliverables, working group reports, position papers and meeting minutes.

3.2.3 Proposed Military Standard Common APSE Interface Set - (MIL-STD-CAIS)

The proposed MIL-STD-CAIS is the specification of the interface set designed by the KIT/KITIA. This is the main objective of the APSE I&T effort. This document is accompanied by various supplemental ones, such as a Rationale and an Implementor's Guidde.

3.2.4 Requirements and Design Criteria -

The Requirements and Design Criteria document is intended to guide the development of CAIS Version 2. As a KIT deliverable, it is second only to the CAIS itself in importance.

3.2.5 APSE I&T Guidelines and Conventions -

The guidelines and conventions covers those aspects of achieving I&T which are not directly addressed by the CAIS. They cover such things as using Ada to write transportable software and the style considerations which promote I&T.

3.3 APSE I&T SCHEDULE

The schedule for the major APSE I&T events is given in Figure 8.

Figure 8 Schedule Summary

4.0 PROVISIONS FOR SPECIAL NEEDS

This APSE I&T Plan emphasizes the development of requirements, conventions and standards. It is unusual in that it is written for a programming language support environment that is in the development state. At this point in development it is essential for the KIT/KITIA to provide an I&T forum and act as a focal point for the Ada community, APSE developers and the DoD. This will provide broad input to the KIT from which a complete, realistic set of I&T requirements, guidelines, conventions and standards will be developed that respond to ongoing APSE development and long term APSE needs.

Normally to achieve APSE I&T the APSE itself would be written in Ada. However, STONEMAN recognizes that "in cases where there is a large current investment in software projects, written originally in other languages", provisions and guidelines must be developed that account for cost effective transitions to Ada environments. In the development of APSE I&T requirements, conventions, and standards the KIT/KITIA should provide cost benefit analysis with respect to their recommendations and decisions concerning implementation.

The STARS program has come to life in the last two years. The need for close coordination between the APSE I&T effort and various STARS projects is becomming increasingly apparent. This is expected to culminate in the shift of APSE I&T sponsorship from the AJPO to the SJPO during the next fiscal year. However, it is not expected that this will have any noticable effect on APSE I&T schedules or objectives. It just helps to ensure that the work on the CAIS and other KIT efforts will be more closely related to the accomplishment of STARS objectives.

5.0 REFERENCE DOCUMENTS

Reference documents applicable to the APSE I&T effort include:

- Requirements For High Order Computer Programming Languages: STEELMAN, DoD, June 1978
- Requirements for Ada Programming Support Environments, STONEMAN, DoD, February 1980
- Kernel Ada Programming Support Environment (KAPSE) Interface Team: Public Report, Volume I, Naval Ocean Systems Center, Technical Document 509, 1 April 1982.
- Kernel Ada Programming Support Environment (KAPSE) Interface Team: Public Report, Volume II, Naval Ocean Systems Center, Technical Document 552, 28 October 1982.
- Kernel Ada Programming Support Environment (KAPSE) Interface Team: Public Report, Volume III, Naval Ocean Systems Center, Technical Document 552, 30 June 1983.
- Kernel Ada Programming Support Environment (KAPSE) Interface Team: Public Report, Volume I, Naval Ocean Systems Center, Technical Document 552, 30 April 1984.
- Proposed Military Standard Common APSE Interface Set, Ada Joint Program Office, 31 January 1985.

APPENDIX A

GLOSSARY OF TERMS

Ada-JUG	Ada-JOVIAL Users Group
AIE	Ada Integrated Environment
AJPO	Ada Joint Program Office
ALS	Ada Language System
ANSI	American National Standards Institute
APSE	Ada Programming Support Environment
DIANA	Descriptive Intermediate Attributed Notation for Ada
DoD	Department of Defense
ECS	Embedded Computer System
FCDSSA	Fleet Combat Direction System Support Activity
GCS	Guidelines, Conventions and Standards
HOLWG	High Order Language Working Group
IOC	Initial Operational Capabilities
ISO	International Standards Organization
I&T	Interoperability and Transportability
JCL	Job Control Language
JHUAPL	John Hopkins University Applied Physics Laboratory
KAPSE	Kernel Ada Programming Support Environment
KIT	KAPSE Interface Team
KITIA	KAPSE Interface Team from Industry and Academia
KITEC	KAPSE Interface Team Executive Committee
MAPSE	Minimal Ada Programming Support Environment
MOA	Memorandum of Agreement
NAC	Naval Avionics Center
NADC	Naval Air Development Center
NAVELEX	Naval Electronic Systems Command
NAVSEA	Naval Sea Systems Command
NOSC	Naval Ocean Systems Center
NRL	Naval Research Laboratory
NSWC	Naval Surface Weapons Center
NUSC	Naval Underwater Systems Center
NWC	Naval Weapons Center
RFP	Request For Proposal
WBS	Work Breadkdown Structure

APPENDIX B

WORK BREAKDOWN SCHEDULE TASK DESCRIPTIONS

WBS ELEMENT DESCRIPTION

ORIGINATOR: NOSC

ORIGINAL DATE: 30 April 1983

REVISION: 1

REVISION DATE: January 1985

WBS ELEMENT NR: 1110

WBS ELEMENT TITLE: Team Management

PART OF WBS ELEMENT: 1100 - Project Management

DELIVERABLES/MILESTONES: Continuous

RESPONSIBILITY: NOSC Code 423 with KITIA Chairman support

TASK DESCRIPTION: Assemble original teams. Coordinate the solicitation and selection of new members. Organize team structure into working groups. Coordinate KIT and KITIA activities separately and together. Organize and coordinate all team meetings. Assign team and working group tasks and see to their completion. Plan and chair meetings. Cooordinate the raising and resolution of issues.

NOTES:

WBS ELEMENT DESCRIPTION

ORIGINATOR: NOSC

ORIGINAL DATE: 30 April 1983

REVISION: 2

REVISION DATE: January 1985

WBS ELEMENT NR: 1120

WBS ELEMENT TITLE: Presentations and Briefings

PART OF WBS ELEMENT: 1100 Project Management

DELIVERABLES/MILESTONES:

Project Review	May 1983		
Senior Management Brief	Quarterly		
SIG Ada Conferences	October 1983	October 1985	
	October 1984	October 1986	

RESPONSIBILITY: NOSC Code 423 with AJPO support

TASK DESCRIPTION: Prepare slides and narration on team objectives, status, progress and plans. Present materials at project reviews, senior management briefings, SIG Ada conferences, symposia, etc.

NOTES:

WBS ELEMENT DESCRIPTION	ORIGINAL DATE: 30 April 1983
ORIGINATOR: NOSC	REVISION: 2
	REVISION DATE: January 1985

WBS ELEMENT NR: 1130

WBS ELEMENT TITLE: Coordination with Software for Adaptable Reliable Systems (STARS)

PART OF WBS ELEMENT: 1100 Project Management

DELIVERABLES/MILESTONES: Continuous

RESPONSIBILITY: NOSC Code 423 with AJPO

TASK DESCRIPTION: Attend STARS workshops. Cooperate with STARS personnel to assure proper incorporation of KIT/KITIA work into STARS plans. Participate in Joint Service Software Engineering Environment (JSSEE) team meetings and Software Engineering Environment Area Coordinating Team activities.

NOTES: It is anticipated that the KIT effort will transfer to STARS JPO sponsorship during fiscal year 1986.

WBS ELEMENT DESCRIPTION

ORIGINATOR: NOSC

ORIGINAL DATE: 30 April 1983

REVISION: 1

REVISION DATE: January 1985

WBS ELEMENT NR: 1140

WBS ELEMENT TITLE: Coodination with Standards Community

PART OF WBS ELEMENT: 1100 Project Management

DELIVERABLES/MILESTONES: Continuous

RESPONSIBILITY: NOSC Code 423 with AJPO support

TASK DESCRIPTION: Keep standards community apprised of team activities and progress. Submit descriptions and reports as requested. Locate and track relevant standards activities.

NOTES:

WBS ELEMENT DESCRIPTION

ORIGINAL DATE: 30 April 1983

ORIGINATOR: NOSC

REVISION: 1

REVISION DATE: January 1985

WBS ELEMENT NR: 1150 WBS ELEMENT TITLE: Contracts

PART OF WBS ELEMENT: 1100 Project Management

DELIVERABLES/MILESTONES: Continuous

RESPONSIBILITY: NOSC Code 423

TASK DESCRIPTION: Initiate contracts and/or tasking necessary to achieve project objectives. At minimum, this includes contracts for tools and general support. Monitor progress including reviews and examination of deliverables. Coordinate the incorporation of results of contracts into general KIT/KITIA work.

NOTES:

WBS ELEMENT DESCRIPTION

ORIGINATOR: NOSC

ORIGINAL DATE: 30 April 1983

REVISION: 2

REVISION DATE: January 1985

WBS ELEMENT NR: 1210

WBS ELEMENT TITLE: Management Plan

PART OF WBS ELEMENT: 1200 Planning

DELIVERABLES/MILESTONES: APSE I&T Management Plan

April 1983
January 1984
January 1985
January 1986

RESPONSIBILITY: NOSC Code 423

TASK DESCRIPTION: Plan activities as necessary to complete the APSE I&T project. Document all plans in the APSE I&T Management Plan. Update this plan once a year, or more often if radical changes occur.

NOTES: An earlier version of this plan was published as CDRL Item A001 of Delivery Order #7N45 on TRW Contract N00123-80-D-0242.

WBS ELEMENT DESCRIPTION

ORIGINAL DATE: 30 April 1983

ORIGINATOR: NOSC

REVISION: 2

REVISION DATE: January 1985

WBS ELEMENT NR: 1220

WBS ELEMENT TITLE: Funding Allocation

PART OF WBS ELEMENT: 1200 Planning

DELIVERABLES/MILESTONES: Budget updates as required.

RESPONSIBILITY: NOSC Code 423

TASK DESCRIPTION: Establish budget for project activities. Secure funds as required. Manage the distribution and expenditure of funds by NOSC, contractors and other agencies. Update budget as necessary.

NOTES:

WBS ELEMENT DESCRIPTION

ORIGINATOR: NOSC

ORIGINAL DATE: 30 April 1983

REVISION: 1

REVISION DATE: January 1985

WBS ELEMENT NR: 1230

WBS ELEMENT TITLE: Strategy

PART OF WBS ELEMENT: 1200 Planning

DELIVERABLES/MILESTONES: APSE I&T Implementation Strategy May 1983

RESPONSIBILITY: NOSC Code 423

TASK DESCRIPTION: Establish, plan and document the strategy to be followed by KIT/KITIA in pursuit of APSE I&T objectives. Reflect this strategy in all plans, budgets and task assignments.

NOTES:

WBS ELEMENT DESCRIPTION

ORIGINATOR: NOSC

ORIGINAL DATE: 30 April 1983

REVISION: 1

REVISION DATE: January 1985

WBS ELEMENT NR: 1310

WBS ELEMENT TITLE: Meeting Support

PART OF WBS ELEMENT: 1300 Administrative Support

DELIVERABLES/MILESTONES: All support is required quarterly in conjunction with regular KIT/KITIA meetings. Other support is also required for special meetings and some working group activities.

RESPONSIBILITY: Support Contractor with NOSC Code 423.

TASK DESCRIPTION: Provide technical support required in planning, preparing for, conducting and reporting on APSE I&T meetings. Support includes, but is not limited to, the provision of agendas, discussion copies of papers, meeting arrangements, minutes and attendee lists.

NOTES:

WBS ELEMENT DESCRIPTION

ORIGINAL DATE: 30 April 1985

ORIGINATOR: NOSC

REVISION: 1

REVISION DATE: January 1985

WBS ELEMENT NR: 1320

WBS ELEMENT TITLE: Team Support

PART OF WBS ELEMENT: 1300 Administrative Support

DELIVERABLES/MILESTONES: Continuous

RESPONSIBILITY: Support contractor with NOSC Code 423.

TASK DESCRIPTION: Provide technical support required for maintenance, storage, updating and distribution of documents and data of the APSE I&T project. Support includes, but is not limited to, maintenance of address lists, document control, working paper preparation and MIL NET directory administration, such as for KIT-INFORMATION and various comment directories.

NOTES:

WBS ELEMENT DESCRIPTION

ORIGINATOR: NOSC

ORIGINAL DATE: 30 April 1983

REVISION: 2

REVISION DATE: January 1985

WBS ELEMENT NR: 1331

WBS ELEMENT TITLE: Requirements, Guidelines, Conventions and Standards

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PART OF WBS ELEMENT: 1330 Publications/1300 Administarative Support

---

DELIVERABLES/MILESTONES:

Requirements	December 1983
Guidelines/Conventions	June 1985
Standard	December 1984
	December 1986

RESPONSIBILITY: NOSC Code 423 with Support Contractor

TASK DESCRIPTION: Generate final versions of all named documents. Submit them to all appropriate publicatiion processes. Provide for their distribution to the KIT/KITIA and to the public through NTIS.

NOTES: CAIS Version 1.1 is available as NTIS report #A134 825.

WBS ELEMENT DESCRIPTION

ORIGINATOR: NOSC

ORIGINAL DATE: 30 April 1983

REVISION: 2

REVISION DATE: January 1985

WBS ELEMENT NR: 1332 WBS ELEMENT TITLE: Public Reports

PART OF WBS ELEMENT: 1330 Publications/1330 Administrative Support

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DELIVERABLES/MILESTONES:

Public Report Vol.	III	April	1983
Public Report Vol.	IV	April	1984
Public Report Vol.	V	October	1984
Public Report Vol.	VI	April	1985
Public Report Vol.	VII	October	1985
Public Report Vol.	VIII	April	1986
Public Report Vol.	IX	October	1986
Public Report Vol.	X	April	1987

RESPONSIBILITY: NOSC Code 423 with Support Contractor

TASK DESCRIPTION: Generate publishable versions of all public reports. This includes determination and acquisition of contents, reformatting as necessary, organization, submission to publication process, distribution, notification of report availability and maintenance of the notification addressee list. Public distribution will be through NTIS.

NOTES: Volume I is NTIS #AD A1155 590
Volume II is NTIS #AD A123 136
Volume III is NTIS #AD A141 576

WBS ELEMENT DESCRIPTION

ORIGINATOR: NOSC

ORIGINAL DATE: 30 April 1983

REVISION: 1

REVISION DATE: January 1985

WBS ELEMENT NR: 1340

WBS ELEMENT TITLE: Correspondence

PART OF WBS ELEMENT: 1300 Administrative Support

DELIVERABLES/MILESTONES: Continuous

RESPONSIBILITY: All participants

TASK DESCRIPTION: Conduct communications as necessary, particularly using the MIL NET. NOSC requirements in this element include the provision of terminals, ports and other required facilities in support of NOSC's other tasks.

NOTES:

WBS ELEMENT DESCRIPTION	ORIGINAL DATE: 30 April 1983
ORIGINATOR: NOSC	REVISION: 1
	REVISION DATE: January 1985

WBS ELEMENT NR: 1400 WBS ELEMENT TITLE: Configuration Management

PART OF WBS ELEMENT: 1000 APSE I&T Management

DELIVERABLES/MILESTONES:

Configuration Management Report	December 1983
Final Configuration Management Recommendations	January 1987

RESPONSIBILITY: NOSC Code 423 with Support Contractor

TASK DESCRIPTION: Plan for configuration management of tools and other products developed under this project. Perform configuration management during the project.

NOTES:

WBS ELEMENT DESCRIPTION

ORIGINATOR: NOSC

ORIGINAL DATE: 30 April 1983

REVISION:

REVISION DATE: January 1985

WBS ELEMENT NR: 2110

WBS ELEMENT TITLE: Relevant Research

PART OF WBS ELEMENT: 2100 Resouce Reviews

DELIVERABLES/MILESTONES: Continuous

RESPONSIBILITY: All participants

TASK DESCRIPTION: Review literature and documentation applicable to I&T requirements, guideline, conventions and standards.

NOTES:

WBS ELEMENT DESCRIPTION

ORIGINATOR: NOSC

ORIGINAL DATE: 30 April 1983

REVISION:

REVISION DATE:

WBS ELEMENT NR: 2120

WBS ELEMENT TITLE: Existing Standards

PART OF WBS ELEMENT: 2100 Resource Reviews

DELIVERABLES/MILESTONES: Continuous

RESPONSIBILITY: All participants

TASK DESCRIPTION: Locate and examine relevant standards. Use and/or incorporate relevant standards as found to be appropriate and applicable.

NOTES: As an example of this, the Operating System Command and Response Language (OSCRL) User Requirements, Functional Requirements and Design Criteria have been used as models for the APSE I&T Requirements and Criteria. The OSCRL documents were developed by X3H1.

WBS ELEMENT DESCRIPTION

ORIGINAL DATE: 30 April 1983

ORIGINATOR: NOSC

REVISION:

REVISION DATE:

WBS ELEMENT NR: 2210

WBS ELEMENT TITLE: Definitions and Categories

PART OF WBS ELEMENT: 2200 Requirements Development

DELIVERABLES/MILESTONES: KAPSE Interface Worksheets December 1983

RESPONSIBILITY: All participants

TASK DESCRIPTION: Develop definitions of all relevant terms, particularly "interoperability" and "transportability". Develop categories of interfaces and KAPSE Interface Worksheets describing each of them.

NOTES: Completed

WBS ELEMENT DESCRIPTION

ORIGINATOR: NOSC

ORIGINAL DATE: 30 April 1983

REVISION: 2

REVISION DATE: January 1985

WBS ELEMENT NR: 2220

WBS ELEMENT TITLE: Requirements and Design Criteria

PART OF WBS ELEMENT: 2220 Requirements Development

DELIVERABLES/MILESTONES:

Draft Requirements and Design Criteria	April	1984
Revision Requirements and Design Criteria	July	1985
Final Requirements and Design Criteria	January	1986

RESPONSIBILITY: All participants

TASK DESCRIPTION: Develop functional requirements and interface design criteria for a set of interfaces which will achieve APSE I&T. Document and analyze these requirements and criteria. Analysis will be conducted through public review as well as team review and will determine completeness, consistency and feasibility.

NOTES:

WBS ELEMENT DESCRIPTION

ORIGINAL DATE: 30 April 1983

ORIGINATOR: NOSC

REVISION: 2

REVISION DATE: January 1985

WBS ELEMENT NR: 2300

WBS ELEMENT TITLE: Special Studies

PART OF WBS ELEMENT: 2000 APSE I&T Analysis

DELIVERABLES/MILESTONES: Workshops and reports as appropriate

Configuration Management workshop	June 1983
Configuration Management report	October 1983

RESPONSIBILITY: Various participants

TASK DESCRIPTION: Conduct technical analyses and studies as required. These special studies may include such topics as command languages, configuration management, STONEMAN revision and risks and cost benefits associated with various levels of I&T.

NOTES:

WBS ELEMENT DESCRIPTION

ORIGINAL DATE: 30 April 1983

ORIGINATOR: NOSC

REVISION:

REVISION DATE:

WBS ELEMENT NR: 3100

WBS ELEMENT TITLE: Guidelines and Conventions Development

PART OF WBS ELEMENT: 3000 APSE I&T Standards

DELIVERABLES/MILESTONES:

APSE I&T Guidelines and Conventions Review Draft	April 1984
APSE I&T Guidelines and Conventions Revision	October 1985
APSE I&T Guidelines and Conventions Final	January 1987

RESPONSIBILITY: All participants

TASK DESCRIPTION: Develop guidelines and conventions for achieving I&T. These supplement and further explain the standard, covering those ideas and approaches that have not been included in the standard as yet but which are believed to contribute to the achievement of I&T.

NOTES:

WBS ELEMENT DESCRIPTION	ORIGINAL DATE: 30 April 1983
ORIGINATOR: NOSC	REVISION: 2
	REVISION DATE: January 1985

WBS ELEMENT NR: 3200 WBS ELEMENT TITLE: Specification Development

PART OF WBS ELEMENT: 3000 APSE I&T Standards

DELIVERABLES/MILESTONES:

Common APSE Interface Set Specification Review	April	1984
CAIS Version 1 (Proposed MIL-STD)	January	1985
CAIS Version 2 Review Draft	January	1986
CAIS Version 2 (Proposed MIL-STD)	January	1987
CAIS Version 2 MIL-STD	December	1987

RESPONSIBILITY: NOSC Code 423 and all participants

TASK DESCRIPTION: Develop the set of interface specifications which will be recommended to the AJPO for standardization. Review and analyze these with respect to conformance with the requiements and criteria and to consistency, completeness and feasibility.

NOTES:

WBS ELEMENT DESCRIPTION

ORIGINATOR: NOSC

ORIGINAL DATE: 30 April 1983

REVISION: 2

REVISION DATE: January 1985

WBS ELEMENT NR: 3310

WBS ELEMENT TITLE: Compliance Procedures

PART OF WBS ELEMENT: 3300 Compliance

DELIVERABLES/MILESTONES:

Draft Compliance Procedures	June	1984
Revised Compliance Procedures	October	1985
Final Compliance Procedures	January	1987

RESPONSIBILITY: NOSC Code 423 with Support Contractor

TASK DESCRIPTION: Develop procedures for determining compliance of an APSE implementation with APSE I&T requirements, guidelines, conventions and standards. Apply these procedures experimentally to the I&T tools and the AIE and ALS. The results of this task will influence the form the standard specification will take. Coordinate with AJPO Evaluation and Validation (E&V) team.

NOTES: This compliance work will be conducted in close cooperation with the AJPO Evaluation and Validation team and wil form the basis of the KIT/KITIA's recommendations to this team.

WBS ELEMENT DESCRIPTION

ORIGINATOR: NOSC

ORIGINAL DATE: 30 April 1983

REVISION: 1

REVISION DATE: January 1985

WBS ELEMENT NR: 3320 WBS ELEMENT TITLE: Validation Recommendations

---

PART OF WBS ELEMENT: 3300 Compliance

DELIVERABLES/MILESTONES:	Validation Recommendations	December 1985
	Validation Recommendations	January 1987

RESPONSIBILITY: NOSC Code 423 with Support Contractor

TASK DESCRIPTION: Review the results of the development and application of the Compliance Procedures (WBS 3310). Formulate recommendations for the AJPO and its Evaluation and Validation team.

NOTES:

WBS ELEMENT DESCRIPTION

ORIGINATOR: NOSC

ORIGINAL DATE: 30 April 1983

REVISION: 2

REVISION DATE: January 1985

WBS ELEMENT NR: 3410

WBS ELEMENT TITLE: Experimental Implementation

PART OF WBS ELEMENT: 3400 Common APSE Interfce Set Analysis

DELIVERABLES/MILESTONES:	Implementation Report	June 1985
	Implementation Report	June 1986
	Implementation Report	June 1987

RESPONSIBILITY: NOSC Code 423 with Support Contractors

TASK DESCRIPTION: Experimentally implement and exercise portions of the proposed common APSE interface set in order to investigate feasibility, completeness, etc. Report results as feedback to be incorporated in final common APSE interface set specification.

NOTES:

WBS ELEMENT DESCRIPTION

ORIGINATOR: NOSC

ORIGINAL DATE: 30 April 1983

REVISION: 2

REVISION DATE: January 1985

WBS ELEMENT NR: 3420

WBS ELEMENT TITLE: Public Review

PART OF WBS ELEMENT: 3400 Common APSE Interface Set Analysis

DELIVERABLES/MILESTONES:

Review Version 1	November	1984
Review Version 2	June	1986
Review Version 2	June	1987

RESPONSIBILITY: NOSC Code 423

TASK DESCRIPTION: Present the proposed standard for widespread public review, including an open review meeting. Incorporate feedback in final document.

NOTES:

WBS ELEMENT DESCRIPTION

ORIGINATOR: NOSC

ORIGINAL DATE: 30 April 1983

REVISION: 1

REVISION DATE: January 1985

WBS ELEMENT NR: 3500 WBS ELEMENT TITLE: Standardization Process

---

PART OF WBS ELEMENT: 3000 APSE I&T Standards

DELIVERABLES/MILESTONES:

Initiate effort	May 1985
Standardize CAIS Version 1	December 1985
Standardize CAIS Version 2	December 1987

RESPONSIBILITY: NOSC Code 423 with AJPO

TASK DESCRIPTION: Determine steps required to achieve standardization of the proposed interface set. Pursue standardization.

NOTES: This activity alone among all these tasks may be expected to continue beyond the lifetime of the KIT/KITIA.

WBS ELEMENT DESCRIPTION	ORIGINAL DATE: 30 April 1983
ORIGINATOR: NOSC	REVISION: 2
	REVISION DATE: January 1985

WBS ELEMENT NR: 4100 WBS ELEMENT TITLE: Plans and Acquisition

---

PART OF WBS ELEMENT: 4000 APSE I&T Tools

DELIVERABLES/MILESTONES:	Plans	July 1982
	Acquisition	October 1983

RESPONSIBILITY: NOSC Code 423

TASK DESCRIPTION: Identify the objectives, criteria and requirements to be used for the selection of three or more APSE tools. These tools will be used to further analyze interface requirements. Initiate acquisition of such tools.

NOTES: Completed

WBS ELEMENT DESCRIPTION	ORIGINAL DATE: 30 April 1983
ORIGINATOR: NOSC	REVISION: 2
	REVISION DATE: January 1985

WBS ELEMENT NR: 4200 WBS ELEMENT TITLE: Tool Development

PART OF WBS ELEMENT: 4000 APSE I&T Tools

DELIVERABLES/MILESTONES:		
	CMS Design	June 1983
	AIM Implementation	June 1985
	AIM Transport Experiment	August 1985

RESPONSIBILITY: Selected Contractors

TASK DESCRIPTION: Design, develop and test tools in a local environment. Provide insights into interface issues as they arise development and integration.

NOTES:

WBS ELEMENT DESCRIPTION

ORIGINATOR: NOSC

ORIGINAL DATE: 30 April 1983

REVISION: 1

REVISION DATE: January 1985

WBS ELEMENT NR: 4300 WBS ELEMENT TITLE: Test and Analysis

PART OF WBS ELEMENT: 4000 APSE I&T Tools

DELIVERABLES/MILESTONES: Test Reports June 1985

RESPONSIBILITY: NOSC Code 423 with Support Contractor

TASK DESCRIPTION: Develop test applications and analyses for determining performance of APSE I&T tools in the AIE and ALS. Apply these to tools as they are completed.

NOTES:

WBS ELEMENT DESCRIPTION

ORIGINATOR: NOSC

ORIGINAL DATE: 30 April 1983

REVISION: 1

REVISION DATE: January 1985

WBS ELEMENT NR: 4400

WBS ELEMENT TITLE: Maintenance and Modifications

PART OF WBS ELEMENT: 4000 APSE I&T Tools

DELIVERABLES/MILESTONES: As required

RESPONSIBILITY: NOSC Code 423 and Contractors

TASK DESCRIPTION: Provide maintenance of APSE I&T tools as required after their development. Modify tools in accordance with needs to correct inadequacies of to respond to changing requiremnts or enviroments.

NOTES:

WBS ELEMENT DESCRIPTION

ORIGINATOR: NOSC

ORIGINAL DATE: 30 April 1983

REVISION: 1

REVISION DATE: January 1985

WBS ELEMENT NR: 5100

WBS ELEMENT TITLE: Public Reviews of AIE and ALS

PART OF WBS ELEMENT: 5000 APSE I&T Coordination with Implementation Efforts

---

DELIVERABLES/MILESTONES: Public Review Reports July 1982 (ALS)
July 1983 (AIE)

RESPONSIBILITY: NOSC Code 831

TASK DESCRIPTION: Coordinate the establishment and notification of review teams. Determine docuemnts or systems to be reviewed and arrange for distribution of copies to members of review teams. Receive all team review reports and correlate into report to AJPO and AIE/ALS sponsor.

NOTES: Completed

WBS ELEMENT DESCRIPTION

ORIGINATOR: NOSC

ORIGINAL DATE: 30 April 1983

REVISION: 2

REVISION DATE: January 1985

WBS ELEMENT NR: 5200

WBS ELEMENT TITLE: Initial Common APSE Interface Set Development

---

PART OF WBS ELEMENT: 5000 APSE I&T Coordination with Implementation Efforts

---

DELIVERABLES/MILESTONES:

Initial CAIS Draft Report	September 1983
Initial MIL-STD CAIS	January 1985

RESPONSIBILITY: Selected participants with NOSC Code 423

TASK DESCRIPTION: Review AIE and ALS to determine a set of interfaces which is implementable in both of these systems. Develop a specification report documenting these interfaces. This task is to be accomplished with participation of AIE and ALS personnel.

NOTES: Completed

WBS ELEMENT DESCRIPTION

ORIGINAL DATE: 30 April 1983

ORIGINATOR: NOSC

REVISION: 1

REVISION DATE: January 1985

WBS ELEMENT NR: 5310

WBS ELEMENT TITLE: KIT/KITIA Coordination

PART OF WBS ELEMENT: 5300 AIE/ALS I&T Analysis

DELIVERABLES/MILESTONES: Continuous

RESPONSIBILITY: NOSC Code 423

TASK DESCRIPTION: Provide channels of communication between KIT/KITIA members and government and contractor personnel involved in the AIE and ALS developments. Arrange for meetings and distribution of relevant documents. Provide feedback to AIE and ALs developers.

NOTES:

WBS ELEMENT DESCRIPTION

ORIGINAL DATE: 30 April 1983

ORIGINATOR: NOSC

REVISION: 1

REVISION DATE: January 1985

WBS ELEMENT NR: 5320

WBS ELEMENT TITLE: Analysis And Recommendations

PART OF WBS ELEMENT: 5300 AIE/ALS I&T Analysis

DELIVERABLES/MILESTONES: ALS Analysis Report May 1984

RESPONSIBILITY: Various participants

TASK DESCRIPTION: Analyze AIE and ALS interfaces with respect to I&T. Provide recommendations for evaluation of each system to meet the interface set as it is put forward for standardization.

NOTES:

WBS ELEMENT DESCRIPTION

ORIGINAL DATE: 30 April 1983

ORIGINATOR: NOSC

REVISION:

REVISION DATE: January 1985

WBS ELEMENT NR: 5400

WBS ELEMENT TITLE: Liaison with Other Implementations

PART OF WBS ELEMENT: 5000 APSE I&T Coordination with Implementation Efforts

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DELIVERABLES/MILESTONES: Continuous

RESPONSIBILITY: All participants

TASK DESCRIPTION: Maintain awareness of and contact with groups who are doing non-DoD APSE implementations. Solicit their inputs and provide information on KIT/KITIA activities. Examples of such groups are the UK, IABG in W. Germany, the EEC, ROLM and UC Irvine.

NOTES:

OFFICE OF THE UNDER SECRETARY OF DEFENSE

WASHINGTON D C 20301

31 JANUARY 1985

RESEARCH AND
ENGINEERING
(R&AT)

Dear CAIS Reviewer:

The Common APSE Interface Set (CAIS) has been developed to facilitate interoperability and transportability between APSEs. Its development was directed by a January 3, 1982 Memorandum of Agreement between the three Services and the Deputy Under Secretary of Defense for Research and Engineering (Acquisition Management). In that memorandum, the Services agreed to establish a set of interfaces upon which formal coordination as a military standard could begin. However, the CAIS is new and there is very little experience with it as yet. Therefore, its establishment as a military standard must be accompanied by a clear statement of the policy regarding its application to projects and contracts.

The attached is a proposed policy statement regarding appropriate application of CAIS Version 1 once it is approved as a military standard. The community at large has expressed a great deal of concern over the potential for misapplication of this interface set when it becomes a military standard. Therefore, we are submitting this draft policy statement for your review in addition to the MIL-STD-CAIS document itself. It is requested that you use the same comment procedures for returning feedback on this draft policy statement as for the CAIS document itself.

Robert F. Mathis

Robert F. Mathis
Director
STARS Joint Program Office

Attachment

PROPOSED CAIS POLICIES

1. Objective: The objective behind the creation of the Common APSE Interface Set (CAIS) is to promote the portability of tools and data between APSEs. The CAIS has been formulated to provide those interfaces most commonly required by tools in the course of their normal operations. When the CAIS has matured to the point of wide acceptance by industry, the DoD will move to apply this standard to the DoD-funded environments.

2. Purpose: This set of interfaces is being issued as a military standard in order to allow its application to government contracts. The principal purpose of such application is to allow contracts to specify the use of the CAIS in experimental implementations whose objective is to learn about the viability, feasibility, implementability and usability of the interface set as a component of a programming support environment. Implementations of this proposed interface set should provide knowledge about implementation of its features and feedback to the CAIS designers relevant to the development of Version 2 of the CAIS.

3. Proper Uses: Proper applications of this standard to contracts include: (1) prototype implementations of the interface set, either wholly or in part; (2) prototype implementations of tools written to run on top of a CAIS implementation; (3) implementation/comparison studies designed for such purposes as determining the probable ease of implementing the CAIS on a new operating system or bare machine or comparing the features available in the CAIS with those considered essential in another operating system; and (4) experimental studies designed to utilize a prototype CAIS and/or tool implementation in order to gather information regarding performance, usability, viability, etc.

4. Improper Uses: It is not intended that the CAIS Version 1 military standard be imposed on any development or maintenance project whose primary purpose is not explicitly to experiment with its implementation or that would be unnecessarily risking total project success on the (unproven) viability of the current CAIS. The CAIS should not be imposed nonchalantly or arbitrarily or without a clear understanding of the potential costs and risks involved.

5. Feedback: All uses made of the CAIS should require at least one report intended to provide feedback to the CAIS designers regarding the pros and cons of its implementation and use, ease or difficulty encountered with particular features, and suggestions for improvements to either the form or technical content of the military standard document.

NOTE: This draft, dated 31 January 1985, prepared by the KAPSE Interface Team and KAPSE Interface Team from Industry and Academia CAIS Working Group for the Ada* Joint Program Office, has not been approved and is subject to modification.
DO NOT USE PRIOR TO APPROVAL.
(Project IPSC/ECRS 0208)

PROPOSED
MIL-STD-CAIS
31 JANUARY 1985

MILITARY STANDARD COMMON APSE INTERFACE SET (CAIS)

AREA ECRS

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DEPARTMENT of DEFENSE
Washington, DC 20302

Common APSE Interface Set

MIL-STD-

1. This Military Standard is approved for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to KIT/KITIA CAIS Working Group and sent to Patricia Oberndorf, Naval Ocean Systems Center, Code 423, San Diego, CA, 92152-5000 by using the self addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FOREWORD

This document has been prepared in response to the Memorandum of Agreement signed by the Undersecretary of Defense and the Assistant Secretaries of the Air Force, Army, and Navy. The memorandum established agreement for defining a set of common interfaces for the Department of Defense (DoD) Ada Programming Support Environment (APSEs) to promote Ada tool transportability and interoperability. The initial interfaces for the CAIS were derived from the Ada Integrated Environment (AIE) and the Ada Language System (ALS). Since then the CAIS has been expanded to be implementable as part of a wide variety of APSEs. It is anticipated that the CAIS will evolve to meet new needs. Through the acceptance of this standard, it is anticipated that the source level portability of Ada software tools will be enhanced for both DoD and non-DoD users.

The authors of this document include technical representatives from the two DoD APSE contractors, representatives from the DoD's Kernel Ada Programming Support Environment (KAPSE) Interface Team (KIT), and volunteer representatives from the KAPSE Interface Team from Industry and Academia (KITIA).

The initial effort for definition of the CAIS was begun in September 1982 by the following members of the KAPSE Interface Team (KIT): J. Foidl (TRW), J. Kramer (Institute for Defense Analyses), P. Oberndorf (Naval Ocean Systems Center), T. Taft (Intermetrics), R. Thall (SofTech) and W. Wilder (NAVSEA PMS-408). In February 1983 the design team was expanded to include LCDR B. Schaar (Ada Joint Program Office), T.Harrison (Texas Instruments) and KAPSE Interface Team from Industry and Academia (KITIA) members: H. Fischer (Litton Data Systems), E. Lamb (Bell Labs), T. Lyons (Software Sciences Ltd., U.K.). D. McGonagle (General Electric), H. Morse (Frey Federal Systems), E. Ploedereder (Tartan Laboratories), H. Willman (Raytheon), and L. Yelowitz (Ford Aerospace). During 1984, the following people assisted in preparation of this document: F. Belz (TRW) and the TRW prototype team, K. Connolly (TRW), S. Ferdman (Data General), G. Fitch (Intermetrics), R. Gouw (TRW), B. Grant (Intermetrics), N. Lee (Institute for Defense Analyses), J. Long (TRW), and R. Robinson (Institute for Defense Analyses). Additional constructive criticism and direction was provided by G. Myers (Naval Ocean Systems Center), O. Roubine (Informatique Internationale), and the general memberships of the KIT and KITIA, as well as many independent reviewers. The Ada Joint Program Office is particularly grateful to these KITIA members and their companies for providing the time and resources that significantly contributed to this document.

This document was prepared with the Unilogic Ltd. SCRIBE typeset tool on the TRW Software Productivity Project development environment.

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1. SCOPE

1.1. Purpose

This document provides specifications for a set of Ada packages, with their intended semantics, which together form the set of common interfaces for Ada Programming Support Environments (APSEs). This set of interfaces is known as the Common APSE Interface Set (CAIS). This interface set is designed to promote the source-level portability of Ada programs, particularly Ada software development tools.

The CAIS applies to Ada Programming Support Environments which are to become the basic software life-cycle environments for Department of Defense (DoD) mission critical computer systems (MCCS). Those Ada programs that are used in support of software development are defined as *tools*. This includes the spectrum of support software from project management through code development, configuration management and life-cycle support. Tools are not restricted to only those software items normally associated with program generation, such as editors, compilers, debuggers, and linker-loaders. Groups of tools that are composed of a number of independent but interrelated programs (such as a debugger which is related to a specific compiler) are classed as *tool sets*[1].

Since the goal of the CAIS is to promote interoperability and transportability of Ada software across DoD APSEs, the following definitions of these terms are provided.

> *Interoperability* is defined as the ability of APSEs to exchange data base objects and their relationships in forms usable by tools and user programs without conversion. *Transportability* of an APSE tool is defined as the ability of the tool to be installed on a different KAPSE; the tool must perform with the same functionality in both APSEs. Transportability is measured in the degree to which this installation can be accomplished without reprogramming. Portability and transferability are commonly used synonyms.[2]

The CAIS is intended to evolve as APSEs are implemented, as tools are transported, and as tool interoperability issues are encountered. Tools written in Ada, using only the packages described herein, should be transportable between CAIS implementations. Where tools function as a set, the CAIS facilitates transportability of the tool set as a whole; tools might not be individually transportable because they depend on inputs from other tools in the set.

1.2. Content

The CAIS establishes interface requirements for the transportability of Ada tool sets to be used in Department of Defense (DoD) APSEs. Strict adherence to this interface set will ensure that Ada tool sets will possess the highest degree of transportability across conforming APSEs.

The scope of the CAIS includes interfaces to those services, traditionally provided by an operating system, that affect tool transportability. Ideally, all APSE tools would be implementable using only the Ada language and the CAIS. The CAIS is intended to provide the transportability interfaces most often required by common software development tools and includes four interface areas:

a. Node Model. This area presents a model for the CAIS in which contents, relationships and attributes of nodes are defined. Also included are the foundations for access control and access synchronization.

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[1] *Requirements for Ada Programming Support Environments, STONEMAN*: Department of Defense: February 1980.

[2] *KAPSE Interface Team: Public Report*, Volume I, 1 April 1982: p. C-1.

b. Processes. This area covers program invocation and control.

c. Input and Output. This area covers file input and output, basic device input and output support, special device control facilities, and interprocess communication.

d. Utilities. This area covers list operations useful for manipulation of parameters and attribute values.

1.3. Excluded and deferred topics

During the design of the CAIS it was determined that interfaces for environments which are not software development environments (for example, interfaces on target systems) and interfaces for multilingual environments should be explicitly excluded. It has been decided that backup facilities will be supported transparently by the CAIS implementation. While the interface issues of most aspects of environments were considered, the complete resolution of several areas has been deferred until later revisions of the CAIS. These areas are:

a. Configuration management. The current CAIS supports facilities for configuration control including keeping versions, referencing the latest revision, identifying the state of an object, etc.; but it does not implement a particular methodology. Currently deferred is the decision whether or not the CAIS should enforce a particular configuration management approach and, if so, what particular methodology should be chosen.

b. Device control and resource management. The current CAIS provides control facilities for scroll, page and form terminals and magnetic tape drives. Currently deferred is the decision as to what additional devices or resources must be supported by the CAIS. Such resources and devices might include printers, disk drives, color terminals, vector- and bit-addressable graphics devices, processor memory, processor time, communication paths, etc. Also deferred is a decision regarding which other American National Standards Institute or International Standards Organization interfaces to adopt, such as the ISO/DIS 7942 Graphical Kernel System (GKS).

c. Distributed environments. The existing CAIS packages are intended to be implementable on a distributed set of processors, but in a manner that is transparent to a tool. Currently deferred is the decision whether or not to provide to the user explicit CAIS interfaces to control the distribution of the environment, including designation of where nodes exist and where execution takes place. Note that a set of distributed processors could include one or more target machines.

d. Inter-tool interfaces. The current CAIS does not define inter-tool calling sequences or data formats such as the data format within the compilation/program library system, the text format within editing systems, the command processor language syntax, the message formats of a mail system, or the interaction between the run-time system and debugger tools. Currently deferred are decisions regarding what inter-tool data should become part of the standard, what form such interfaces should take, and whether or not to place constraints on the run-time system to provide process execution information.

e. Interoperability. The current CAIS provides only a very primitive, text-oriented interface for transferring files between a CAIS implementation and the operating system on which it may reside. It does not define external representations of data for transfer between environments or between a host and target.

f. Typing methodology. The current CAIS provides attributes and relations which can be

used by tool sets to constrain nodes, attributes, and relations, but it does not enforce a particular methodology. Currently deferred is a decision whether or not the CAIS should enforce a particular, more complete typing methodology and what kind of CAIS interfaces should be made available to support it.

g. Archiving. The current CAIS does not define facilities for archiving data. Currently deferred is a decision regarding the form that archiving interfaces should take.

2. REFERENCED DOCUMENTS

2.1. Issues of documents

The following documents of the issue in effect on date of invitation for bids or request for proposal form a part of this standard to the extent specified herein.

[LRM]: Reference Manual for the Ada Programming Language, ANSI/MIL-STD-1815A; United States Department of Defense; January 1983.

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2. Other publications

The following documents form a part of the standard to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

[ANSI 78]: American National Standards Institute, *Magnetic Tape Labels and File Structure for Information Interchange (ANSI Standard x3.27-1978)*. (Application for copies should be addressed to American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018)

[DACS]: DACS Glossary, a Bibliography of Software Engineering Terms, GLOS-1, October 1979, Data and Analysis Center for Software. (Application for copies should be addressed to Data and Analysis Center for Software, RADC/ISISI, Griffiss AFB, NY 13441)

[IEEE]: IEEE Standard Glossary of Software Engineering Terminology, ANSI/IEEE Std. 729-1983. (Application for copies should be addressed to Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018)

[STONEMAN]: Requirements for Ada Programming Support Environments, STONEMAN; Department of Defense; February 1980.

[TCSEC]: Department of Defense Trusted Computer System Evaluation Criteria, Department of Defense Computer Security Center, CSC-STD-001-83, 15 August 1983. (Application for copies should be addressed to Department of Defense, Computer Security Center, Office of Standards and Products, Attention: Chief, Computer Security Standards, Fort George G. Meade, Maryland 20755.)

[UK Ada Study]: United Kingdom Ada Study Final Technical Report, Volume I, London, Department of Industry, 1981. (Application for copies should be addressed to Scientific Information Office, British Defence Staff, British Embassy, 3100 Massachusetts Avenue, NW, Washington, D.C. 20008.)

[WEBS]: Webster's New Collegiate Dictionary, G.&C. Merriam Company, Springfield, Massachusetts, 1979.

3. DEFINITIONS

The following is an alphabetical listing of terms which are used in the description of the CAIS. Where a document named in Section 2 was used to obtain the definition, the definition is preceded by a bracketed reference to that document.

abort - [IEEE] To terminate a process prior to completion.

access - [TCSEC] A specific type of interaction between a subject and an object that results in the flow of information from one to the other.

access checking - The operation of checking access rights against those rights required for the intended operation, according to the access control rules, and either permitting or denying the intended operation.

access control - [TCSEC] (1) discretionary access control: A means of restricting access to objects based on the identity of subjects and/or groups to which they belong. The controls are discretionary in the sense that a subject with a certain access permission is capable of passing that permission (perhaps indirectly) on to any other subject. (2) mandatory access control: A means of restricting access to objects based on the sensitivity (as represented by a label) of the information contained in the objects and the formal authorization (i.e., clearance) of subjects to access information of such sensitivity. In the CAIS, this includes specification of access rights, access control rules and checking of access rights in accordance with these rules.

access control constraints - The resulting restrictions placed on certain kinds of operations by access control.

access control information - All the information required to perform access checking.

access control rules - The rules describing the correlations between access rights and those rights required for an intended operation.

access relationship - A relationship of the predefined relation ACCESS.

access rights - Descriptions of the kinds of operations which can be performed.

access to a node - Reading or writing of the contents of the node, reading or writing of attributes of the node, reading or writing of relationships emanating from a node or of their attributes, and traversing a node as implied by a pathname.

accessible - The subject has (adopted a role which has) been granted the access right EXISTENCE to the object.

active position - The position at which a terminal operation is to be performed.

Ada Programming Support Environment (APSE) - [UK Ada Study, STONEMAN] A set of hardware and software facilities whose purpose is to support the development and maintenance of Ada applications software throughout its life-cycle with particular emphasis on software for embedded computer applications. The principal features are the database, the interfaces and the tool set.

adopt a role - The action of a process to acquire the access rights which have been or will be

granted by an object to adopters of that role; in the CAIS this is accomplished by establishing a secondary relationship of the predefined relation ADOPTED_ROLE from the process node to the node representing the role.

adopted role of a process - The access rights associated with the node that is the target of a relationship of the predefined relation ADOPTED_ROLE emanating from the process node or with any group node one of whose permanent members is the target of such a relationship.

advance (of an active position) - (1) Scroll or page terminal: Occurs whenever (i) the row number of a new position is greater than the row number of the old or (ii) the row number of the new position is the same and the column number of the new position is greater than that of the old. (2) Form terminal: Occurs whenever the indices of its position are incremented.

approved access rights - Access rights whose names appear in resulting rights lists of relevant grant items for which either (i) the necessary right is null or (ii) the necessary right is an approved access right.

area qualifier - A designator for the beginning of a qualified area.

attribute - A named value associated with a node or relationship which provides information about that node or relationship.

closed node handle - A node handle which is not associated with any node.

contents - A file or process associated with a CAIS node.

couple - To establish a correlation between a queue file and a secondary storage file. If the queue file is a copy queue file, its initial contents is a copy of the secondary storage file to which it is coupled; if the queue file is a mimic queue file, its initial contents is a copy of the secondary storage file to which it is coupled, and elements that are written to the mimic queue file are appended to its coupled file.

current job - The root process node of the tree containing the current process node; represented by the predefined relation CURRENT_JOB.

current node - The node that is currently the focus or context for the activities of the current process; represented by the predefined relation CURRENT_NODE.

current process - The currently executing process making the call to a CAIS operation. Pathnames are interpreted in the context of the current process.

current user - The user's top-level node; represented by the secondary relationship of the predefined relation CURRENT_USER.

dependent process - A process other than a root process.

device [WEBS] - A piece of equipment or a mechanism designed to serve a special purpose or perform a special function.

device name - The keys of a primary relationship of the predefined relation DEVICE.

discretionary access control - See **access control**.

element (of a file) - A value of the generic data type with which the input and output package was instantiated; see [LRM] for additional information.

end position - The position of a form identified by the highest row and column indices of the form.

external file - [LRM 14.1.1 - Ada external file] Values input from the external environment of the program, or output to the environment, are considered to occupy external files. An external file can be anything external to the program that can produce a value to be read or receive a value to be written.

file - See **external file**.

file handle - An object of type FILE_TYPE which is used to identify an internal file.

file node - A node whose contents are an Ada external file, e.g., a host system file, a device, or a queue.

form - A form is a two-dimensional matrix of character positions.

group - A collection of nodes representing roles and identified by a structural node with emanating relationships of the predefined relations POTENTIAL_MEMBER and PERMANENT_MEMBER identifying each of the group's members. A member may be a user top-level node, a node representing the executable image of a program, or a node representing a group.

illegal identification - A node identification in which the pathname or the relationship key or relation name is syntactically illegal with respect to the syntax defined in Table I.

inaccessible - The subject has not (adopted a role which has) been granted the access right of EXISTENCE to the object.

initiate - To place a program into execution; in the CAIS, this means a process node is created, a process is created as its contents, required resources are allocated, and execution is started.

initiated process - The process whose program has been placed into execution.

initiating process - The process placing a program into execution.

interface - [DACS] A shared boundary.

internal file - A file which is internal to a CAIS process. Such a file is identified by a file handle.

iterator - A variable which provides the bookkeeping information necessary for iteration over nodes (a node iterator) or attributes (an attribute iterator).

job - A process node tree, spanned by primary relationships, which develops under a root process node as other (dependent) processes are initiated for the user.

key - See **relationship key**. The key of a node is the relationship key of the last element of the node's pathname.

label group (of a magnetic tape) - One of the following: (i) a volume header and a file header label, (ii) a file header label, or (iii) an end-of-file label.

latest key - The final part of a key that is automatically assigned lexicographically following all previous keys for the same relation names and initial relationship key character sequence for a given node.

list- [IEEE] An ordered set of items of data; in the CAIS, an entity of type LIST_TYPE whose value is a linearly ordered set of data elements.

list item - A data element in a list.

mandatory access control - See **access control**.

named item - a list item which has name associated with it.

named list - a list whose items are all named.

node - A representation within the CAIS of an entity relevant to the APSE.

node handle - An Ada object of type NODE_TYPE which is used to identify a CAIS node; it is internal to a process.

non-existing node - A node which has never been created.

object - [TCSEC] A passive entity that contains or receives information. In the CAIS, any node may be an object.

obtainable - A node is obtainable if it is created and not deleted.

open node handle - A node handle that has been assigned to a particular node.

parent - The source node of a primary relationship; also the target of a relationship of the predefined relation PARENT.

path - A sequence of relationships connecting one node to another. Starting from a given node, a path is followed by traversing a sequence of relationships until the desired node is reached.

path element - A portion of a pathname representing the traversal of a single relationship; a single relation name and relationship key pair.

pathname - A name for a path consisting of the concatenation of the names of the traversed relationships in the path in the same order in which they are traversed.

permanent member - A group member which is intrinsically related to the group via primary relationships of the predefined relation PERMANENT_MEMBER.

position (of a terminal) - A place in an output device in which a single, printable ASCII character may be graphically displayed.

potential member - A group member that may dynamically acquire membership in the group; represented by a node that is the target of a secondary relationship of the predefined relation POTENTIAL_MEMBER emanating from that group node or from any of that group nodes' descendants.

descendant (of a node) - Any node which is reachable from other nodes via primary relationships.

pragmatics - Constraints imposed by an implementation that are not defined by the syntax or semantics of the CAIS.

primary relationship - The initial relationship established from an existing node to a newly created node during its creation. The existence of a node is determined by the existence of the primary relationship of which it is the target.

process - The execution of an Ada program, including all its tasks.

process node - A node whose contents represent a CAIS process.

program - [LRM] A program is composed of a number of compilation units, one of which is a subprogram called the main program.

qualified area - A contiguous group of positions in a form that share a common set of characteristics.

queue - [IEEE] A list that is accessed in a first-in, first-out manner.

relation - In the node model, a class of relationships sharing the same name.

relation name - The string that identifies a relation.

relationship - In the node model, an edge of the directed graph which emanates from a source node and terminates at a target node. A relationship is an instance of a relation.

relationship key - The string that distinguishes a relationship from other relationships having the same relation name and emanating from the same node.

relevant grant items - The items in values of GRANT attributes of relationships of the relation ACCESS emanating from the object and pointing at any node representing a role which is an adopted role of the subject or representing a group, one of whose permanent members is an adopted role of the subject.

role - A set of access rights that a subject can acquire.

root process node - The initial process node created when a user logs on to an APSE or when a new job is created via the CREATE_JOB interface.

secondary relationship - An arbitrary connection which is established between two existing nodes.

security level - [TCSEC] The combination of a hierarchical classification and a set of non-hierarchical categories that represents the sensitivity of information.

source node - The node from which a relationship emanates.

start position (of a form terminal) - The position of a form identified by row one, column one.

structural node - A node without contents. Structural nodes are used strictly as holders of relationships and attributes.

subject - [TCSEC] An active entity, generally in the form of a person, process, or device, that causes information to flow among objects or changes the system state. In the CAIS, a subject is always a process.

system-level node - The root of the CAIS primary relationship tree which spans the entire node structure.

target node - The node at which a relationship terminates.

task - [LRM] A task operates in parallel with other parts of the program.

termination of a process - Termination (see [LRM] 9.4) of the execution of the subprogram which is the main program (see [LRM] 10.1) of the process.

token - An internal representation of an identifier which can be manipulated as a list item.

tool - [IEEE - software tool] A computer program used to help develop, test, analyze, or maintain another computer program or its documentation; for example, an automated design tool, compiler, test tool, or maintenance tool.

top-level node - A structural node representing the user. Each user has a top-level node.

track - (1) An open node handle is guaranteed always to refer to the same node, regardless of any changes to relationships that could cause pathnames to become invalid or to refer to different nodes. An open node handle is said to **track** the node to which it refers. (2) Secondary relationships.

traversal of a node - Traversal of a relationship emanating from the node.

traversal of a relationship - The act of following a relationship from its source node to its target node.

unique primary path - The path from the system-level node to a given node traversing only primary relationships. Every node that is not unobtainable has a unique primary path.

unique primary pathname - The pathname associated with the unique primary path.

unnamed item - No name is associated with a list item.

unnamed list - A list whose items are all unnamed.

unobtainable - A node is unobtainable if it is not the target of any primary relationship.

user - An individual, project, or other organizational entity. In the CAIS it is associated with a top-level node.

user name - The key of a primary relationship of the predefined relation USER.

4. GENERAL REQUIREMENTS

4.1. Introduction

The CAIS provides interfaces for data storage and retrieval, data transmission to and from external devices, and activation of programs and control of their execution. In order to achieve uniformity in the interfaces, a single model is used to consistently describe general data storage, devices and executing programs. This approach provides a single model for understanding the CAIS concepts; it provides a uniform understanding of and emphasis on data storage and program control; and it provides a consistent way of expressing interrelations both within and between data and executing programs. This unified model is referred to as the node model.

Section 4.2 discusses how the interfaces are described in the remainder of Section 4 and in Section 5. Section 4.3 describes the node model. Section 4.4 describes the mandatory and discretionary access control model incorporated in the CAIS. Section 4.5 describes limits and constraints not defined by the interfaces. Section 5 provides detailed descriptions of the interfaces. Section 6 provides information on the intended use of this document and relevant keywords for use by automated document retrieval systems.

Appendix A provides descriptions of the entities predefined in the CAIS. This appendix constitutes a mandatory part of this standard.

Appendix B provides a set of the Ada package specifications which have been organized for compilation of the CAIS interfaces. Appendix C provides a set of the corresponding Ada package bodies. Appendix D provides a list of all CAIS procedures and functions organized by the packages in which they appear.

4.2. Method of description

The specifications of the CAIS interfaces are divided into two parts:

a. the syntax as defined by a canonical Ada package specification, and

b. the semantics as defined by the descriptions both of the general node model and of the particular packages and procedures.

The Ada package specifications given in this document are termed canonical because they are representative of the form of the allowable actual Ada package specifications in any particular CAIS implementation. The packages which together provide an implementation of these specifications must have indistinguishable syntax and semantics from those stated herein.

4.2.1. Allowable differences

The packages which together provide a particular implementation of the CAIS must have the following properties:

a. Any Ada program that is legal and not erroneous in the presence of the canonical package specifications as library units must be legal and not erroneous if the canonical packages are replaced by the packages of a particular CAIS implementation and the names of additional library units required for the implementation of this particular CAIS are not in conflict with the names of library units required by the Ada program. [Note: It is recommended,

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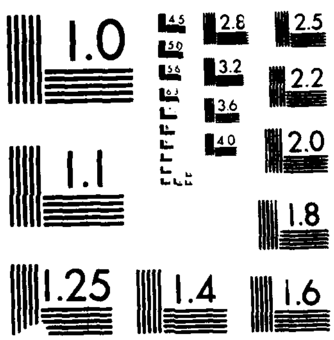
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although not required, that any Ada program that is illegal in the presence of the canonical package specifications as library units is also illegal if the canonical packages are replaced by the packages of a particular CAIS implementation.]

b. The CAIS interfaces provided by the subprograms declared in the packages of a particular CAIS implementation must have the semantics described in this document for the corresponding subprograms in the canonical package specifications.

The actual Ada package specifications of a particular implementation may differ from the canonical specifications as long as properties (a) and (b) are preserved.

4.2.2. Semantic descriptions

The interface semantics are described in most cases through narrative. These narratives are divided into as many as five paragraphs. The *Purpose* paragraph describes the function of the interface. The *Parameters* paragraph briefly describes each of the parameters, and the *Exceptions* paragraph briefly describes the conditions under which each exception is raised. Any relevant information that does not fall under one of these three headings is included in a *Notes* paragraph. In cases where an interface is overloaded and the additional versions can be described in terms of the basic form of the interface and other CAIS interfaces, these versions are described in a paragraph, called Additional Interfaces, using Ada. This method of presenting the semantics of the Additional Interfaces is a conceptual model. It does not imply that the Additional Interfaces must be implemented in terms of the existing ones exactly as specified, merely that their behavior is equivalent to such an implementation. The semantics described in the Purpose, Parameters and Exceptions apply only to the principal interface; the Additional Interfaces may have additional semantics as implied by the given package bodies.

4.2.3. Typographical conventions

This document follows the typographical conventions of [LRM] where these are not in conflict with those of a MIL-STD. In particular:

a. **boldface** type is used for Ada language reserved words,

b. UPPER CASE is used for Ada language identifiers which are not reserved words,

c. in the text, syntactic category names are written in normal typeface with any embedded underscores removed,

d. in the text, where reference is made to the actual value of an Ada variable (for example, a procedure parameter), the Ada name is used in normal typeface. However, where reference is made to the Ada object itself (see [LRM] 3.2 for this use of the word object), then the Ada name is given in upper case, including any embedded underscores. For example, from [LRM] 14.2.1 paragraphs 17, 18 and 19

function MODE(FILE: **in** FILE_TYPE) **return** FILE_MODE;

Returns the current mode of the given file.

but

The exception STATUS_ERROR is raised if the file is not open.

e. at the place where a technical term is first introduced and defined in the text, the term is given in an *italic* typeface.

4.3. CAIS node model

The CAIS provides interfaces for administering entities relevant during the software life-cycle such as files, directories, processes and devices. These entities have various properties and may have a variety of interrelations. The CAIS model uses the concept of a *node* as the carrier of information about an entity. It uses the concept of a *relationship* for representing an interrelation between two entities and the concept of an *attribute* for representing a property of an entity or of an interrelation.

The model of the structure underlying the CAIS and reflecting the interrelations of entities is a directed graph of nodes, which form the vertices of the graph, and relationships, which form the edges of the graph. This model is a conceptual model. It does not imply that an implementation of the CAIS must use a directed graph to represent nodes and their relationships.

Both nodes and relationships possess attributes describing properties of the entities represented by nodes and of interrelations represented by relationships.

4.3.1. Nodes

The CAIS identifies three different kinds of nodes: structural nodes, file nodes and process nodes. A node may have contents, relationships and attributes. The *contents* vary with the kind of node. If a node is a *file node*, the contents is an Ada external file. There are four types of CAIS supported Ada external files: secondary storage, queue, terminal, and magnetic tape. The Ada external file may represent a host file, a device (such as a terminal or tape drive) or a queue (as used for process intercommunication). If a node is a *process node*, the contents is a representation of the execution of an Ada program. If a node is a *structural node*, there is no contents and the node is used strictly as a holder of relationships and attributes. The kind of a node is a predefined and implicitly established attribute on every relationship which points to the node.

Nodes can be created, renamed, accessed (as part of other operations), and deleted.

4.3.2. Processes

A *process* is the CAIS mechanism used to represent the execution of an Ada program. A process is represented as the contents of a process node. The process node and its attributes and relationships are also used to bind to an execution the resources (such as files and devices) required by the process. Taken together, the process node, its attributes, relationships and contents are used in the CAIS to manage the dynamics of the execution of a program. Each time execution of a program is *initiated*, a process node is created, the process is created, the necessary resources to support the execution of the program are allocated to the process, and execution is started. The newly created process is called the *initiated process*, while the process which caused the creation of that process is called the *initiating process*.

A single CAIS process represents the execution of a single Ada program, even when that program includes multiple tasks. Within the process, Ada tasks execute in parallel (proceed independently) and synchronize in accordance with the rules in [LRM] 9, paragraph 5:

> Parallel tasks may be implemented on multicomputers, multiprocessors, or with interleaved execution on a single physical processor. On the other hand, whenever an implementation can

detect that the same effect can be guaranteed if parts of the actions of a given [Ada] task are executed by different physical processors acting in parallel, it may choose to execute them in this way; in such a case several physical processors implement a single logical processor.

When a task makes a CAIS call, execution of that task is blocked until the CAIS call returns control to the task. Other tasks in the same process may continue to execute in parallel, subject to the Ada tasking rules. If calls on CAIS interfaces are enacted concurrently, the CAIS does not specify their order of execution.

Processes are analogous to Ada tasks in that they execute logically in parallel, have mechanisms for interprocess synchronization, and can exchange data with other processes. However, processes and Ada tasks are dissimilar in certain critical ways. Data, procedures or tasks in one process cannot be directly referenced from another process. Also, while tasks in a program are bound together prior to execution time (at compile or link time), processes are not bound together except by cooperation using CAIS facilities at run time.

4.3.3. Input and output

Ada input and output in [LRM] 14 involves the transfer of data to and from Ada external files. CAIS input and output uses the same model and involves the transfer of data to and from the contents of CAIS file nodes. These file nodes may represent disk or other secondary storage files, magnetic tape drives, terminals, or queues.

CAIS file nodes represent information about and contain Ada external files. The underlying model for the contents of such a node is that of a file of data items, accessible either sequentially or directly by some index. The packages specified in Section 5.3 provide facilities that operate on CAIS external files.

Implementations of the standard Ada packages SEQUENTIAL_IO, DIRECT_IO, and TEXT_IO specified in the [LRM] that operate upon CAIS files are to be constructed such that they meet the Ada standard and for CREATE and OPEN procedures:

1. The semantics of the use of the default value of the FORM parameter FORM : IN string := "" is specified within the context of the node model.

2. The syntax and semantics of the non empty FORM parameter is specified within the context of the NODE model.

3. Nothing in the implementation can violate the concistancy of the CAIS NODE model.

The interfaces in the package MAGNETIC_TAPE have been modeled on the American National Standards Institute standards in [ANSI 78].

4.3.4. Relationships and relations

The relationships of CAIS nodes form the edges of a directed graph; they are used to build conventional hierarchical directory and process structures (see Section 5.1.5 STRUCTURAL_NODES and Section 5.2.2 PROCESS_CONTROL) as well as arbitrary directed-graph structures. Relationships are unidirectional and are said to emanate from a *source node* and to terminate at a *target node*. A relationship may also have attributes describing properties of the relationship.

Because any node may have many relationships representing many different classes of connections,

the concept of a *relation* is introduced to categorize the relationships. Relations identify the nature of relationships, and relationships are instances of relations. Certain basic relations are predefined by the CAIS. Their semantics are explained in the following sections. Additional predefined relations are introduced in Section 5 and are listed in Appendix A. Relations may also be defined by a user. The CAIS associates only the relation name with user-defined relations; no other semantics are supported.

Each relationship is identified by a relation name and a relationship key. The *relation name* identifies the relation, and the *relationship key* distinguishes between multiple relationships each bearing the same relation name and emanating from a given node.

Nodes in the environment are attainable by following relationships. Operations are provided to *traverse a relationship*, that is, to follow a relationship from its source node to its target node.

4.3.4.1. Kinds of relationships

There are two kinds of relationships: primary and secondary. When a node is created, an initial relationship is established from some other node to the newly created node. This initial relationship is called the *primary relationship* to this new node, and the source node of this initial relationship is called the *parent* node. In addition, the new node will be connected back to this parent via a relationship of the predefined relation PARENT. There is no requirement that all primary relationships emanating from a node have the same relation name. Primary relationships form a strictly hierarchical tree; that is, for every node (except the root) there is one and only one sequence of primary relationships leading to it from the node that is the root of the tree. No cycles can be constructed using only primary relationships.

The primary relationship is broken by DELETE_NODE or DELETE_TREE operations. After deletion of the primary relationship to a node, the node is said to be *unobtainable*. A *non-existing node* is one which has never been created. RENAME operations may be used to make the primary relationship to a node emanate from a different node which becomes the new parent of the node. The operations DELETE_NODE, DELETE_TREE, RENAME, and the operations creating nodes are the only operations that manipulate primary relationships. They maintain a state in which each node has exactly one parent and a unique primary pathname (see Section 4.3.5).

Secondary relationships are arbitrary connections which may be established between two existing nodes; secondary relationships may form an arbitrary directed graph. User-defined secondary relationships are created with the LINK procedure and broken with the UNLINK procedure. Secondary relationships may exist to unobtainable nodes.

4.3.4.2. Basic predefined relations

The CAIS predefines certain relations. Relationships belonging to a predefined relation cannot be created, modified, or deleted by means of the CAIS interfaces and their relationship keys are the empty string, except where explicitly noted. The semantics of the predefined relations which are basic to the node model, as well as related concepts of the CAIS, are explained in this Section and Section 4.4. The basic predefined relations explained in this Section are USER, DEVICE, JOB, CURRENT_JOB, CURRENT_USER and CURRENT_NODE.

The CAIS node model incorporates the notion of a user. A *user* may be an individual, project, or other organizational entity; this notion is not equated with only an individual person. Each user has one *top-level node*. This top-level node is a structural node which represents the user and from it the user can access other structural, file and process nodes.

The CAIS node model incorporates the notion of a system. This notion provides the means of administering all the entities represented within one CAIS implementation. This notion implies the existence of a *system-level* node which acts as the root of the CAIS primary relationship tree spanning the entire node structure. Each top-level node is reachable from the system-level node along a primary relationship of the predefined relation USER emanating from the system-level node. The key of this relationship is the *user name*. Each user name has a top-level node associated with it. The system-level node cannot be accessed explicitly by the user via the CAIS interfaces. It may only be manipulated by interfaces outside the CAIS, e.g., to add new relationships of the predefined relation USER emanating from the system-level node.

The CAIS node model incorporates the notion of devices. Each device is described by a file node. This file node is reachable from the system-level node along a primary relationship of the predefined relation DEVICE emanating from the system-level node. The key of this relationship is the *device name*. The CAIS does not define interfaces for creating nodes which represent devices; such interfaces are to be provided outside the CAIS.

The CAIS node model incorporates the notion of a job. When a user logs onto the APSE or calls the CREATE_JOB procedure, a *root process node* is created which often represents a command interpreter or other user-communication process. It is left to each CAIS implementation to set up a methodology for users to log onto the APSE and for enforcing any constraints that limit the top-level nodes at which users may log on. After logging onto the APSE, the user will be regarded by the CAIS as the user associated with the top-level node at which he logged on. A process node tree, spanned by primary relationships, develops from the root process node as other processes (called *dependent* processes) are initiated for the user. A particular user may have several root processes nodes concurrently. Each corresponding process node tree is referred to as a *job*. The predefined JOB relation is provided for locating each of the root process nodes from the user's top-level node. A primary relationship of the predefined relation JOB emanates from each user's top-level node to the root process node of each of the user's jobs. The key of this relationship is assigned by the mechanism of interpreting the LATEST_KEY constant (see Section 4.3.5) unless otherwise specified in the CREATE_JOB procedure call.

While the CAIS does not specify an interface for creating the initial root process node when a user logs onto the APSE, the effect is to be the same as a call to the CREATE_JOB procedure. The secondary relationships which the implementation must establish are found in TABLE IX. In particular, secondary relationships of the predefined relations USER and DEVICE must be established, with the appropriate user and device names as keys. These relationships emanate from the root process node being created to an implementation-defined subset of top-level nodes and file nodes representing devices, respectively. Dependent process nodes in the job inherit these relationships. File nodes representing devices and top-level nodes of other users can be reached from a process node via a relationship of the relation DEVICE or USER and a relationship key which is interpreted as the respective device or user name.

CURRENT_JOB, CURRENT_USER, and CURRENT_NODE are predefined relations which provide a convenient means for identifying other CAIS nodes. The relationship of the predefined relation CURRENT_JOB always points to the root process node of a process node's job. The relationship of the predefined relation CURRENT_USER always points to the user's top-level node. The relationship of the predefined relation CURRENT_NODE can be used to point to a node which represents the process's current focus or context for its activities. The process node can thus use the CURRENT_NODE for a base node when specifying pathnames (see Section 4.3.5). The CAIS requires that, when a root process node is created, it has a relationship of the predefined relation CURRENT_NODE pointing to the top-level node for the user.

The node model makes use of the concept of a *current process*. This concept is implicit in all calls to CAIS operations and refers to the process for the currently executing program making the call. It defines the context in which the parameters are to be interpreted. In particular, pathnames are determined in the context of the current process.

4.3.5. Paths and pathnames

Every accessible node may be reached by following a sequence of relationships; this sequence is called the *path* to the node. A path starts at a known (not necessarily top-level) node and follows a sequence of relationships to a desired node. The path from the system-level node to a given node traversing only primary relationships is called the *unique primary path* to the given node.

Paths are specified using a pathname syntax. Starting from a given node, a path is followed by traversing a sequence of relationships until the desired node is reached. The *pathname* for this path is made up of the concatenation of the names of the traversed relationships in the same order in which they are traversed.

The syntax of a pathname is a sequence of path elements, each *path element* representing the traversal of a single relationship. A path element is an apostrophe (pronounced "tick") followed by a relation name and a parenthesized relationship key.

Relation names and relationship keys follow the syntax of Ada identifiers. Upper and lower case are treated as equivalent within such identifiers. If the relationship key of a path element is the empty string, the parentheses may be omitted. Thus, 'PARENT and 'PARENT() refer to the same node.

The CAIS predefines the relation DOT. If the relation name in a path element is DOT, then the path element may be represented simply by a dot ('.') followed by the relationship key. Thus, 'DOT(TRACKER) is the same as .TRACKER. Relationship keys of relationships of the DOT relation may not be the empty string. Instances of the DOT relation may be manipulated by the user within access right constraints. Relationships of the DOT relation are not restricted to be primary relationships and are not associated with any other CAIS-specific semantics.

The starting point for interpretation of a pathname is always the current process node. A pathname may begin simply with a relationship key, not prefixed by either an apostrophe or '.' . This is taken to mean interpretation following a relationship emanating from the current node with the relation name DOT and with the given key. Thus LANDING_SYSTEM is the same as 'CURRENT_NODE.LANDING_SYSTEM.

For example, all of the following are legal node pathnames, and they would all refer to the same node if the relationship of the predefined relation points to the same node as 'USER(JONES).TRACKER and the relationship of the predefined relation points to the same node as 'USER(JONES):

a. LANDING_SYSTEM'WITH_UNIT(RADAR)

b. 'USER(JONES).TRACKER.LANDING_SYSTEM'WITH_UNIT(RADAR)

c. 'CURRENT_USER.TRACKER.LANDING_SYSTEM'WITH_UNIT(RADAR)

A pathname may also be a ":" . This is interpreted as referring to the current process node.

By convention, a relationship key ending in '#' is taken to represent the LATEST_KEY (lexicographically last). When creating a node or relationship, use of '#' to end the final relationship

key of a pathname will cause a relationship key to be automatically assigned, lexicographically following all previous relationship keys for the same relation and initial relationship key character sequence of relationships emanating from that particular node.

Identification of a node is provided by a pathname or by a given node and an identification of a relationship emanating from the given node by means of its relation name and relationship key. The phrase *to identify* means to provide an identification for a node. A node identification is considered an *illegal identification* if either the pathname or the relationship key or the relation name is syntactically illegal with respect to the syntax defined in Table I. An illegal identification is treated as an identification for a non-existing node.

A pathname implies *traversal of a node* if a relationship emanating from the node is traversed; consequently all nodes on the path to a node are traversed, while the node at the end of the path is not traversed. An identification that would require traversal of an unobtainable or inaccessible node is treated as the identification for a non-existing node.

The pathname associated with the unique primary path is called the *unique primary pathname* of the node. The unique primary pathname of the node is syntactically identical to, and therefore can be used as, a pathname whose interpretation starts at the current process node. It always starts with 'USER(user_name).

When identifying a node, use of "#" to end any relationship key in the pathname is interpreted as the relationship key of an existing relationship, lexicographically following all other keys for the same relation and initial relationship key character sequence of relationships emanating from that particular node.

Table I. Pathname BNF

```
path name::= relationship_key{path_element} |
          path_element{path_element}    | :

path_element::= 'relation_name [ ( [ relationship_key ] ) ] |
            .relationship_key


relation_name::= identifier

relationship_key::= identifier  | [ identifier ] #
```

Note: the relation name DOT must have a non-empty relationship key.

Notation:
1. Words - syntactic categories
2. [ ] - optional items
3. { } - an item repeated zero or more times
4. | - separates alternatives

4.3.6. Attributes

Both nodes and relationships may have attributes which provide information about the node or relationship. Attributes are identified by an attribute name. Each attribute has a name and has a list of the values assigned to it, represented using the LIST_UTILITIES type called LIST_TYPE (see Section 5.4.1).

Relation names and attribute names both have the same form (that is, the syntax of an Ada identifier). Relation names and node attribute names for a given node must be different from each other; relationship attribute names are in a separate name space.

The CAIS predefines certain attributes which are discussed in Section 5 and listed in Appendix A. Predefined attributes cannot be created, modified or deleted by the user, except where explicitly noted. The user can also create and manipulate user-defined attributes (see Section 5.1.3).

4.4. Discretionary and mandatory access control

The CAIS specifies mechanisms for discretionary and mandatory access control (see [TCSEC]). These specifications are only recommendations. Alternate discretionary or mandatory access control mechanisms can be substituted by an implementation provided that the semantics of all interfaces in Section 5 (with the exception of Section 5.1.4) are implemented as specified.

In the CAIS, *access control* refers to all the aspects of controlling access to information. It consists of:

a. *access control rights* Descriptions of the kinds of operations which can be performed.

b. *access control rules* The rules describing the correlations between access rights and those rights required for an intended operation.

c. *access checking* The operation of checking granted access rights against those rights required for the intended operation according to the access control rules, and either permitting or denying the intended operation.

All of the information required to perform access checking is collectively referred to as *access control information*. The resulting restrictions placed on certain kinds of operations by access control are called *access rights constraints*.

4.4.1. Node access

In the CAIS, the following operations constitute *access to a node*:

a. reading or writing of the contents of the node,

b. reading or writing of attributes of the node,

c. reading or writing of relationships emanating from a node or of their attributes, and

d. traversing a node (see Section 4.3.5).

The phrase "reading relationships" is a convenient short-hand meaning either traversing relationships or reading their attributes. To access a node, then, means to perform any of the above access operations. The phrase "to obtain access" to a node means being permitted to perform certain operations on the node within access right constraints. Access to a node by means of a pathname can only be achieved if the current process has the respective access rights to the node as well as to any node traversed on the path to the node.

In the CAIS, the following operations do not constitute access to a node: closing node handles to a node, opening a node with intent EXISTENCE (see TABLE V), reading or writing of relationships of which a node is the target or of the attributes of such relationships, querying the kind of a node and querying the status of node handles to a node.

A node is *inaccessible* if the current process does not have sufficient discretionary access control rights to have knowledge of the node's existence or if mandatory access controls prevent information flow from the node to the current process. The property of inaccessibility is always relative to the access rights of the currently executing process, while the property of unobtainability is a property of the node alone.

4.4.2. Discretionary access control

Discretionary access control is a means of restricting access to objects based on the identity of subjects and/or groups to which they belong. The controls are discretionary in the sense that a subject with certain access permission is capable of passing that permission (perhaps indirectly) on to any other subject [TCSEC].

In the CAIS, an *object* is any node to be accessed and a *subject* is any process (acting on the behalf of a given user) performing an operation requiring access to an object. Discretionary access control is used to limit access to nodes by processes running programs on behalf of users or groups of users.

An object can have established for it a secondary relationship of the predefined relation ACCESS which specifies the kinds of operations which may be performed on it. A process node may have a secondary relationship of the ADOPTED_ROLE relation established to the same target node as a predefined relation relationship. The information provided by these two kinds of relationships determines the approved access rights which the process has to the object (see Section 4.4.2.3). When the process tries to open the object node, the access rights implied by the INTENT parameter (see Section 5.1) are checked against these approved access rights to determine whether the process can perform the operation on that node.

4.4.2.1. Establishing grantable access rights

An object may be the source node of zero or more secondary relationships of the predefined relation ACCESS (called *access relationships*). Each access relationship has a predefined attribute, called GRANT, which specifies what access rights to the object are grantable to processes (subjects).

In order to limit the set of nodes to which access relationships can be established, the CAIS discretionary access control model requires that, upon creation of a root process node, secondary relationships of the predefined relation ALLOW_ACCESS be created. These relationships emanate from the created root process node to an implementation-defined set of nodes. The CAIS implementation must establish at least the secondary relationship of the predefined relation ALLOW_ACCESS with the user name as key from the root process node to the user top-level node. All such relationships are inherited by the process nodes created under the root process node.

Access relationships and GRANT attributes are established for objects in one of two ways: using the interfaces provided in the package ACCESS_CONTROL or at node creation.

The SET_ACCESS_CONTROL procedure can be used by a process to establish an access relationship between two nodes and to set the value of the GRANT attribute. This procedure can also be used to change the value of the GRANT attribute of an existing access relationship.

Access relationships are also established at node creation. The ACCESS_CONTROL parameter provides the necessary information in two parts. One part provides relationship keys which are used to identify the nodes which will be the targets of the new access relationships. If the current process node has a relationship of the relation ALLOW_ACCESS whose key is one of the keys given in the parameter, then the node identified by that relationship becomes the target of a new access relationship from the created node.

The other part of the ACCESS_CONTROL parameter gives a set of access rights for each relationship key. These access rights become the value of the GRANT attribute of the access relationship created with the corresponding key.

The ACCESS_CONTROL parameter specifies the initial access control information to be established

for a node being created using named Ada aggregate syntax; that is, it consists of a list of items each of which has a name (identifying a target node for an access relationship) followed by a list of values for the GRANT attribute.

For every relationship key named in the list for which the current process node has a relationship of the predefined relation ALLOW_ACCESS, a relationship of the predefined relation ACCESS with the given relationship key and the given access rights value for its GRANT attribute value is created from the new node to the target of the relationship of the predefined relation ALLOW_ACCESS.

4.4.2.2. Adopting a role

In the CAIS, a *role* is associated with a set of access rights that a subject can acquire when it acts under authority of that role. Each role is associated with a CAIS user, a program being executed, or a particular group of users, programs or subgroups. A subject (process) may act under the authority of several roles. Roles can be acquired dynamically.

In the CAIS a role is represented by a node; the associated access rights are determined by access relationships as described in the following sections. This node may be a top-level node representing a user, a node containing the executable image of a program, or a structural node representing a group. The structural node representing a group has relationships emanating from it to the nodes which represent the group's members.

Each group member is identified either by a primary relationship of the predefined relation PERMANENT_MEMBER or by a secondary relationship of the predefined relation POTENTIAL_MEMBER emanating from the group node. The phrase *permanent member* of a group refers to any node reachable from a node representing the group via primary relationships of the predefined relation PERMANENT_MEMBER. The relation PERMANENT_MEMBER may be used to create a hierarchy of nodes representing roles by defining members of a group that are themselves groups. A user top-level node may not be the target of a primary relationship of the predefined relation PERMANENT_MEMBER emanating from a group node due to the restriction that user top-level nodes can only have a primary relationship from the system-level node.

Secondary relationships of the predefined relation POTENTIAL_MEMBER are used to identify those members that may dynamically acquire membership in the group. The phrase *potential member* of a group refers to any node that is the target of a relationship of the predefined relation POTENTIAL_MEMBER from that group or from any of that group's permanent members.

When a process *adopts* a particular role, a secondary relationship of the predefined relation ADOPTED_ROLE is created from the process node to the node representing the role. There may be multiple relationships of the predefined relation ADOPTED_ROLE emanating from a process node. Roles are adopted either at creation of the process node or explicitly. When a process is created, it implicitly adopts the role represented by the file node containing an executable image of the program it is executing. When a root process node is created, it implicitly adopts the role represented by its current user node. When any process node is created, it implicitly inherits the relationships of the relation ADOPTED_ROLE of the node of its creating process. A process may explicitly adopt a role associated with a group using the ADOPT procedure (Section 5.1.4.4). For a process to adopt a role associated with a given group, a node representing some other adopted role of the process must be a potential member of the given group.

4.4.2.3. Evaluating access rights

The value of the GRANT attribute is a list whose syntax is given by the BNF in TABLE II. The necessary right is an access right, and the resulting rights are a list of access rights. An access right name has the syntax of an Ada identifier.

Table II. GRANT attribute value BNF

```
grant_attribute_value::= ( [ grant_item {,grant_item}])

grant_item::= ([necessary_right=>] resulting_rights_list)

necessary_right::= identifier

resulting_rights_list::= identifier |
                         ( identifier {, identifier})
```

Notation:
1. Words - syntactic categories
2. [ ] - optional items
3. { } - an item repeated zero or more times
4. | - separates alternatives

The syntax is consistent with that given in Section 5.4. The interfaces in Section 5.4 can be used to construct and manipulate values of the GRANT attribute.

Checking of discretionary access control rights involves relevant grant items and approved access rights, both of which are derived from the values of GRANT attributes. For a given subject and object, *relevant grant items* are the grant items in values of GRANT attributes of relationships of the relation ACCESS emanating from the object and pointing at any node representing a role which is an adopted role of the process subject or representing a group one of whose permanent members is an adopted role of the process subject. *Approved access rights* are access rights whose names appear in resulting rights lists of relevant grant items for which either (1) the necessary right is null or (2) the necessary right is an approved access right.

For example, given a process node SUBJECT, an object OBJECT, and two nodes ROLE1 and ROLE2 representing roles, the following relationships might exist:

a. a relationship of the relation ACCESS from OBJECT to ROLE1 with a GRANT attribute value of (READMAIL=>(READ, WRITE)).

b. a relationship of the relation ACCESS from OBJECT to ROLE2 with a GRANT attribute value of (READMAIL).

c. a relationship of the relation ADOPTED_ROLE from SUBJECT to ROLE1, and

d. a relationship of the relation ADOPTED_ROLE from SUBJECT to ROLE2.

The relevant grant items are *READMAIL* and *READMAIL=>(READ, WRITE)*. The approved access rights for SUBJECT to access OBJECT are (1) READMAIL because the necessary rights of the relevant grant item of the access relationship to ROLE2 is null and (2) READ and WRITE because the necessary right, READMAIL, of the relevant grant item of the access relationship to ROLE1 is approved. FIGURE 1 shows a graphic representation of these relationships.

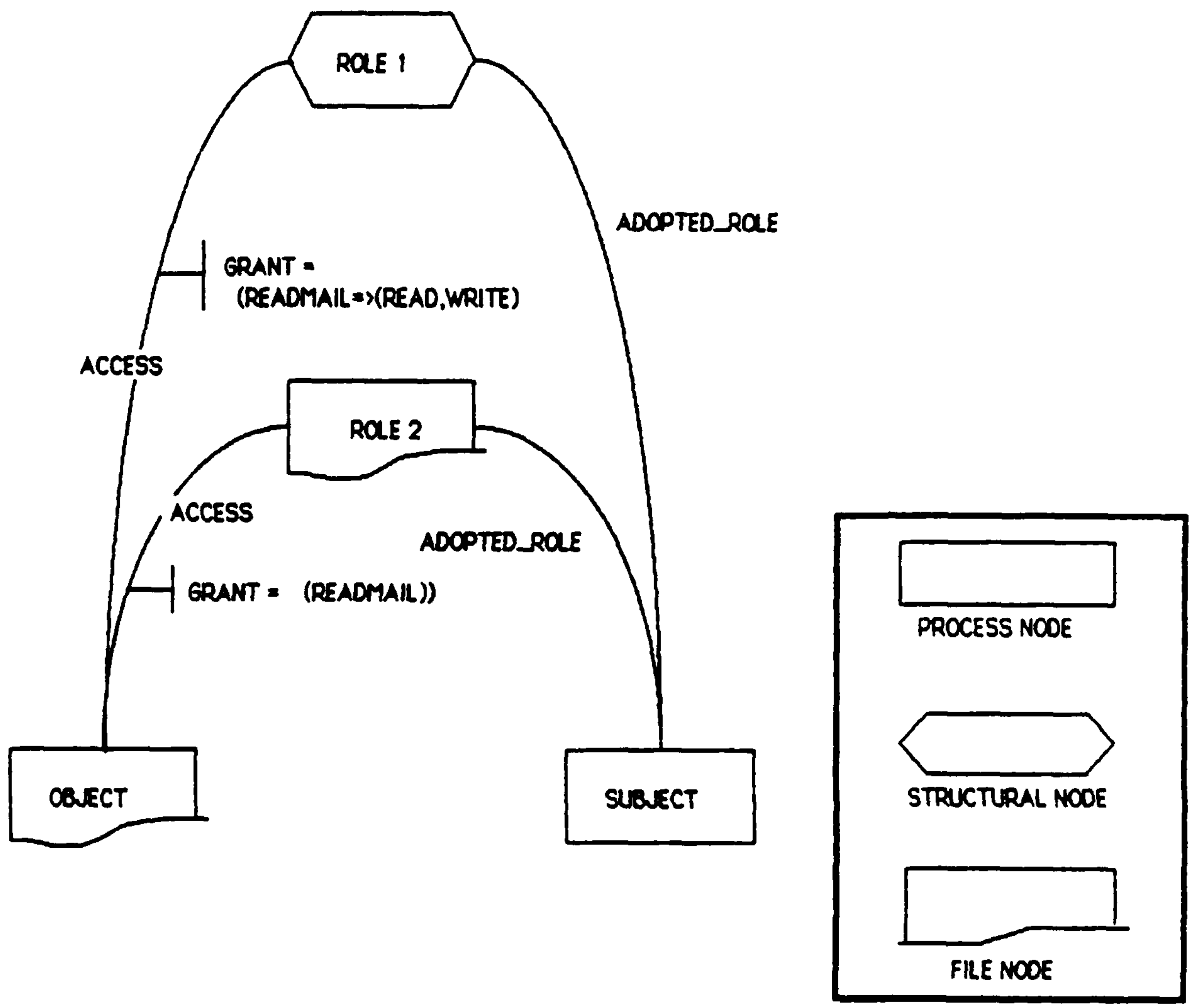

Figure 1. Access relationships

Access rights may be user-defined, but certain access rights have special significance to CAIS operations. In particular, the CAIS recognizes the access rights given in Table III and the kinds of access for which they are necessary or sufficient.

Table III. Predefined access rights

EXISTENCE The minimum access rights without which the object is inaccessible to the subject. Without additional access rights the subject may neither read nor write attributes, relationships or contents of the object.

READ_RELATIONSHIPS
The subject may read attributes of relationships emanating from the object or use it for traversal to another node; the access right EXISTENCE is implicitly granted. This access right is necessary to open the object with intent READ_RELATIONSHIPS.

WRITE_RELATIONSHIPS
The subject may create or delete relationships emanating from the object or may create, delete, or modify attributes of these relationships; the access right EXISTENCE is implicitly granted. This access right is necessary to open the object with intent WRITE_RELATIONSHIPS.

APPEND_RELATIONSHIPS
The subject may create relationships emanating from the object and attributes of these relationships; the access right EXISTENCE is implicitly granted. This access right is necessary to open the object with intent APPEND_RELATIONSHIPS.

READ_ATTRIBUTES
The subject may read attributes of the object; the access right EXISTENCE is implicitly granted. This access right is necessary to open the object with intent READ_ATTRIBUTES.

WRITE_ATTRIBUTES
The subject may create, write, or delete attributes of the object; the access right EXISTENCE is implicitly granted. This access right is necessary to open the object with intent WRITE_ATTRIBUTES.

APPEND_ATTRIBUTES
The subject may create attributes of the object; the access right EXISTENCE is implicitly granted. This access right is necessary to open the object with intent APPEND_ATTRIBUTES.

READ_CONTENTS
The subject may read contents of the object; the access right EXISTENCE is implicitly granted. This access right is necessary to open the object with intent READ_CONTENTS.

WRITE_CONTENTS
The subject may write contents of the object; the access right EXISTENCE is implicitly granted. This access right is necessary to open the object with intent WRITE_CONTENTS granted. This access right is necessary to open the object with intent READ_CONTENTS.

APPEND_CONTENTS
The subject may append contents of the object; the access right EXISTENCE is implicitly granted. This access right is necessary to open the object with intent APPEND_CONTENTS.

READ	This is the union of READ_RELATIONSHIPS, READ_ATTRIBUTES, READ_CONTENTS and EXISTENCE access rights. This access right is necessary to open the object with intent READ. It is sufficient to open the object with intent READ_RELATIONSHIPS, READ_ATTRIBUTES or READ_CONTENTS.
WRITE	This is the union of WRITE_RELATIONSHIPS, WRITE_ATTRIBUTES, WRITE_CONTENTS and EXISTENCE access rights. This access right is necessary to open the object with intent WRITE. It is sufficient to open the object with intent WRITE_RELATIONSHIPS, WRITE_ATTRIBUTES or WRITE_CONTENTS.
APPEND	This is the union of APPEND_RELATIONSHIPS, APPEND_ATTRIBUTES, APPEND_CONTENTS and EXISTENCE access rights. This access right is necessary to open the object with intent APPEND. It is sufficient to open the object with intent APPEND_RELATIONSHIPS, APPEND_ATTRIBUTES or APPEND_CONTENTS.
EXECUTE	The subject may create a process that takes the contents of the object as its executable image; the access right EXISTENCE is implicitly granted. This access right is necessary to open the object with intent EXECUTE.
CONTROL	The subject may modify access control information of the object; the access right EXISTENCE is implicitly granted. This access right is necessary to open the object with intent CONTROL.

4.4.2.4. Discretionary access checking

CAIS access control rules state that any access right required for a subject to access an object must be contained in the set of approved access rights of that object with respect to that subject. The CAIS model allows discretionary access checking to be performed at the time a node handle is opened. At this point access rights implied by the INTENT parameter of the open operation must be a subset of the approved access rights. If this is not the case, the operation is terminated and an exception is raised. For subsequent access using the node handle, the access rights required may be compared to the rights implied by the intent, rather than the approved access rights.

4.4.3. Mandatory access control

> Mandatory access control provides access controls based directly on a comparison of the individual's clearance or authorization for the information and the classification or sensitivity designation of the information being sought [TCSEC].

A mandatory access control classification may be either a hierarchical classification level or a non-hierarchical category. A hierarchical classification level is chosen from an ordered set of classification levels and represents either the sensitivity of the object or the trustworthiness of the subject. In hierarchical classification, the reading of information flows downward towards less sensitive areas, while the creating of information flows upward towards more trustworthy individuals. A subject may obtain read access to an object if the hierarchical classification of the subject is greater than or equal to that of the object. In turn, to obtain write access to the object, a subject's hierarchical classification must be less than or equal to the hierarchical classification of the object.

Each subject and object is assigned zero or more non-hierarchical categories which represent coexisting classifications. A subject may obtain read access to an object if the set of non-hierarchical categories assigned to the subject contains each category assigned to the object. Likewise, a subject may obtain write access to an object if each of the non-hierarchical categories assigned to the subject are included in the set of categories assigned to the object.

A subject must satisfy both hierarchical and non-hierarchical access rights rules to obtain access to an object.

In the CAIS, subjects are CAIS processes, while an object may be any CAIS node. Operations are CAIS operations and are classified as read, write, or read/write operations. Access checking is performed at the time the operation is requested by comparing the classification of the subject with that of the object with respect to the type of operation.

4.4.3.1. Labeling of CAIS nodes

The labeling of nodes is provided by predefined node attributes. A predefined attribute, called SUBJECT_CLASSIFICATION, is assigned to each process node and represents the process' classification as a subject. A predefined attribute, called OBJECT_CLASSIFICATION, is assigned to each node and represents the node's classification as an object. These attributes have a limited function and cannot be read or written directly through the CAIS interfaces. The value of the attribute is a parenthesized list containing two items, the hierarchical classification level and the non-hierarchical category list. The hierarchical classification is a keyword member of the ordered set of hierarchical classification keywords. The non-hierarchical category list is a list of zero or more keyword members of the set of non-hierarchical categories. The hierarchical classification level set and the non-hierarchical category set are implementation-defined. For example, the following are possible classification attribute values:

(TOP_SECRET, (MAIL_USER, OPERATOR, STAFF))

(UNCLASSIFIED, ())

(SECRET, (STAFF))

The BNF for the value of a classification attribute (and of the LEVEL parameter which provides it at node creation) is given in Table IV.

Table IV. Classification attribute value BNF

```
object_classification ::= classification
subject_classification ::= classification
classification ::= ( hierarchical_classification,
   non_hierarchical_categories )
hierarchical_classification ::= keyword
   non_hierarchical_categories ::= ( [ keyword { , keyword } ] )
keyword ::= identifier
```

Notation:
1. Words - syntactic categories
2. [ ] - optional items
3. { } - an item repeated zero or more times
4. | - separates alternatives

4.4.3.2. Labeling of process nodes

When a root process is created, it is assigned subject and object classification labels. The method by which these initial labels are assigned is not specified; however, the labels *shall accurately represent security levels of the specific [users] with which they are associated* [TCSEC]. When any non-root (dependent) process node is created, the creator may specify the classification attributes associated with the node. If no classification is specified, the classification is inherited from the creator. The assigned classification must adhere to the requirements for mandatory access control over write operations.

4.4.3.3. Labeling of non-process nodes

When a non-process object is created, it is assigned an object classification label. The classification label may be specified in the create operation, or it may be inherited from the parent. The assigned classification must adhere to the requirements for mandatory access control over write operations.

4.4.3.4. Labeling of nodes for devices

Certain file nodes representing devices may have a range of classification levels. The classification label of the node of the first process opening a handle to one of these nodes is assigned to the file node while there are any open node handles to the file node. Only when all open node handles have been closed can a new classification label be assigned to the file node.

The range of classification levels is specified by two predefined CAIS node attributes. The attribute HIGHEST_CLASSIFICATION defines the highest allowable object classification label that may be

assigned to the file node. The attribute LOWEST_CLASSIFICATION defines the lowest allowable object classification label that may be assigned to the file node.

When a file node representing the device is opened, the device inherits its security classification label from the first process performing the open operation. If it is not possible to label the node representing the device within the bounds of the attributes HIGHEST_CLASSIFICATION and LOWEST_CLASSIFICATION, the operation fails by raising the exception SECURITY_VIOLATION.

4.4.3.5. Mandatory access checking

When access control is enforced for a given operation, mandatory access control rules are checked. If mandatory access controls are not satisfied, the operation terminates by raising the exception SECURITY_VIOLATION, except where the indication of failure constitutes violation of mandatory access control rules for "read" operations, in which case NAME_ERROR may be raised.

4.5. Pragmatics

This section provides several minimum values for implementation-determined quantities and sizes.

4.5.1. Pragmatics for CAIS node model

Several private types are defined as part of the CAIS node model. The actual implementation of these types may vary from one CAIS implementation to the next. However, it is important to establish certain minimum values for each type to enhance portability.

NAME_STRING
: At least 255 characters must be supported in a CAIS pathname.

RELATIONSHIP_KEY
: At least 80 leading characters must be significant in a relationship key.

ATTRIBUTE_NAME, RELATION_NAME
: At least 80 leading characters must be significant in attribute and relation names.

Tree height
: At least 10 levels of hierarchy must be supported for the primary relationships.

Record size number
: At least 2**15-1 bits per record must be supported.

Open node count
: Each process must be able to have at least 127 nodes open simultaneously.

List
: At least 2**15-1 bits per list must be supported.

4.5.2. Pragmatics for SEQUENTIAL_IO

A CAIS implementation must support generic instantiation of this package with any (non-limited) constrained Ada type whose maximum size in bits (as defined by the attribute ELEMENT_TYPE'SIZE) is at least 2**15-1. A conforming implementation must also support instantiation with unconstrained record types which have default constraints and a maximum size in bits of at least 2**15-1. It may (but need not) use variable length elements to conserve space in the external file.

4.5.3. Pragmatics for DIRECT_IO

Each element of a direct-access file is selected by an integer index of type COUNT. A conforming implementation must at least support a range of indices from one to 2**15-1.

A CAIS implementation must support generic instantiation of this package with any (non-limited) constrained Ada type whose maximum size in bits (as defined by the attribute ELEMENT_TYPE'SIZE) is at least 2**15-1. A conforming implementation must also support instantiation with unconstrained record types which have default constraints and a maximum size in bits of at least 2**15-1. It may (but need not) use variable length elements to conserve space in the external file.

4.5.4. Pragmatics for TEXT_IO

A CAIS implementation must support files with at least 2**15-1 records/lines in total and at least 2**15-1 lines per page. A CAIS implementation must support at least 255 columns per line.

5. DETAILED REQUIREMENTS

The following detailed requirements shall be fulfilled in a manner consistent with the model descriptions given in Section 4 of this standard.

5.1. General node management

This section describes the CAIS interfaces for the general manipulation of nodes, relationships and attributes. These interfaces are defined in five CAIS packages: NODE_DEFINITIONS defines types, subtypes, exceptions, and constants used throughout the CAIS; NODE_MANAGEMENT defines interfaces for general operations on nodes and relationships; ATTRIBUTES defines interfaces for general operations on attributes; ACCESS_CONTROL defines interfaces for setting and adopting access rights; and STRUCTURAL_NODES defines interfaces for the creation of structural nodes.

Specialized interfaces for the manipulation of process and file nodes and of their relationships and attributes are defined in Sections 5.2 and 5.3, respectively.

To simplify manipulation by Ada programs, an Ada type NODE_TYPE is defined for values that represent an internal handle for a node (referred to as a *node handle*. Objects of this type can be associated with a node by means of CAIS procedures, causing an *open node handle* to be assigned to the object. While such an association is in effect, the node handle is said to be open; otherwise, the node handle is said to be closed. Most procedures expect either a parameter of type NODE_TYPE, a pathname, or a combination of a base node (specified by a parameter BASE of type NODE_TYPE) and a path element relative to it, to identify a node.

An open node handle is guaranteed always to refer to the same node, regardless of any changes to relationships that could cause pathnames to become invalid or to refer to different nodes. This behavior is referred to as the *tracking* of nodes by open node handles.

5.1.1. Package NODE_DEFINITIONS

This package defines the Ada type NODE_TYPE. It also defines certain enumeration and string types and exceptions useful for node manipulations.

```
type NODE_TYPE is limited private;

type NODE_KIND is (FILE, STRUCTURAL, PROCESS);

type INTENT_SPECIFICATION is
    (EXISTENCE, READ, WRITE, READ_ATTRIBUTES, WRITE_ATTRIBUTES,
     APPEND_ATTRIBUTES, READ_RELATIONSHIPS, WRITE_RELATIONSHIPS,
     APPEND_RELATIONSHIPS, READ_CONTENTS, WRITE_CONTENTS,
     APPEND_CONTENTS, CONTROL, EXECUTE, EXCLUSIVE_READ,
     EXCLUSIVE_WRITE, EXCLUSIVE_READ_ATTRIBUTES,
     EXCLUSIVE_WRITE_ATTRIBUTES, EXCLUSIVE_APPEND_ATTRIBUTES,
     EXCLUSIVE_READ_RELATIONSHIPS, EXCLUSIVE_WRITE_RELATIONSHIPS,
     EXCLUSIVE_APPEND_RELATIONSHIPS, EXCLUSIVE_READ_CONTENTS,
     EXCLUSIVE_WRITE_CONTENTS, EXCLUSIVE_APPEND_CONTENTS,
     EXCLUSIVE_CONTROL);

type INTENTION is array(POSITIVE range <>) of INTENT_SPECIFICATION;

subtype NAME_STRING       is  STRING;
subtype RELATIONSHIP_KEY  is  STRING;
subtype RELATION_NAME     is  STRING;
```

```
subtype FORM_STRING      is   STRING;
```

NODE_TYPE describes the type for node handles. NODE_KIND is the enumeration of the kinds of nodes. INTENT_SPECIFICATION describes the usage of node handles and is further explained in Section 5.1.2. INTENTION is the type of the parameter INTENT of CAIS procedures which open or change the intent of a node handle, as further explained in Section 5.1.2.

NAME_STRING, RELATIONSHIP_KEY, RELATION_NAME, and FORM_STRING are subtypes for pathnames, relationship keys, and relation names, as well as for form strings (see [LRM] 14). Value of these string subtypes are subject to certain syntactic restrictions whose violation causes exceptions to be raised.

```
CURRENT_USER      : constant NAME_STRING      := "'CURRENT_USER";
CURRENT_NODE      : constant NAME_STRING      := "'CURRENT_NODE";
CURRENT_PROCESS   : constant NAME_STRING      := ":";
LATEST_KEY        : constant RELATIONSHIP_KEY:= "#";
DEFAULT_RELATION: constant RELATION_NAME    := "DOT";
NO_DELAY          : constant DURATION         :='FIRST
```

CURRENT_USER, CURRENT_NODE, and CURRENT_PROCESS are standard pathnames for the current user's top-level node, current node, and current process, respectively. LATEST_KEY and DEFAULT_RELATION are standard names for the latest key and the default relation name, respectively. NO_DELAY is a constant of type DURATION (see [LRM] 9.6) used for time limits.

```
NAME_ERROR          : exception;
USE_ERROR           : exception;
STATUS_ERROR        : exception;
LOCK_ERROR          : exception;
INTENT_VIOLATION    : exception;
ACCESS_VIOLATION    : exception;
SECURITY_VIOLATION  : exception;
```

NAME_ERROR is raised whenever an attempt is made to access a node via a pathname or node handle while the node does not exist, it is unobtainable, discretionary access control constraints for knowledge of existence of a node are violated, or mandatory access controls for 'read' operations are violated. This exception takes precedence over ACCESS_VIOLATION and SECURITY_VIOLATION exceptions.

USE_ERROR is raised whenever a restriction on the use of an interface is violated.

STATUS_ERROR is raised whenever the open status of a node handle does not conform to expectations.

LOCK_ERROR is raised whenever an attempt is made to modify or lock a locked node.

INTENT_VIOLATION is raised whenever an operation is attempted on an open node handle which is in violation of the intent associated with the open node handle.

ACCESS_VIOLATION is raised whenever an operation is attempted which violates access right constraints other than knowledge of existence of the node. ACCESS_VIOLATION is raised only if the conditions for NAME_ERROR are not present.

SECURITY_VIOLATION is raised whenever an operation is attempted which violates mandatory access controls for 'write' operations. SECURITY_VIOLATION is raised only if the conditions for other exceptions are not present.

5.1.2. Package NODE_MANAGEMENT

This package defines the general primitives for manipulating, copying, renaming and deleting nodes and their relationships.

The operations defined in this package are applicable to all nodes, relationships and attributes except where explicitly stated otherwise. These operations do not include the creation of nodes. The creation of structural nodes is performed by the CREATE_NODE procedures of package STRUCTURAL_NODES (see Section 5.1.5), the creation of nodes for processes is performed by INVOKE_PROCESS, SPAWN_PROCESS and CREATE_JOB of package PROCESS_CONTROL (see Section 5.2.2), and the creation of nodes for files is performed by the CREATE procedures of the input and output packages (see Section 5.3).

Three CAIS interfaces for manipulating node handles are: OPEN opens a node handle, CLOSE closes the node handle, and CHANGE_INTENT alters the specification of the intention of node handle usage. In addition, GET_PARENT, GET_CURRENT_NODE, GET_NEXT, OPEN_FILE_NODE and the node creation procedures also open node handles. These interfaces perform access synchronization in accordance with an intent specified by the parameter INTENT.

Operations which open node handles or change their intent are central to general node administration since they manipulate node handles and most other interfaces take node handles as parameters. While such other interfaces may also be provided in overloaded versions, taking pathnames as node identification, these overloaded versions are to be understood as including implicit OPEN calls with appropriate intent specification and a default TIME_LIMIT parameter. Subsequent uses of the phrase 'open operation' may refer to any of the OPEN, GET_CURRENT_NODE, GET_PARENT, GET_NEXT and OPEN_FILE_NODE operations.

One or more of the intents defined in TABLE V can be expressed by the INTENT parameters.

Table V. Intents

EXISTENCE:	The established access right for subsequent operations is to query properties of the node handle and existence of the node only. Locks on the node have no delaying effect.
READ, EXCLUSIVE_READ:	Open and CHANGE_INTENT operations are delayed if the node, its contents, attributes or relationships are locked against read operations. The established access right for subsequent operations is to read node contents, attributes and relationships. For EXCLUSIVE_READ, the node is locked against opens with any write intent as specified in FIGURE 2. Open and change_intent operations are additionally delayed if there are open node handles to the node with write intent.
WRITE, EXCLUSIVE_WRITE:	Open and change_intent operations are delayed if the node, its contents, attributes

or relationships are locked against write operations. The established access right for subsequent operations is to write, create or append to node contents, attributes and relationships.

For EXCLUSIVE_WRITE, the node is locked against opens with any read, write or append intent as specified in FIGURE 2. Open and change_intent operations are additionally delayed if there are open node handles to the node with read, write or append intent.

READ_CONTENTS, EXCLUSIVE_READ_CONTENTS:

Open and change_intent operations are delayed if the node or its contents are locked against read operations. The established access right for subsequent operations is to read the node contents.

For EXCLUSIVE_READ_CONTENTS, the node contents are locked against all opens with write intent as specified in FIGURE 2. Open and change_intent operations are additionally delayed if there are open node handles to the node with intent to write its contents.

WRITE_CONTENTS, EXCLUSIVE_WRITE_CONTENTS:

Open and change_intent operations are delayed if the node or its contents are locked against write operations. The established access right for subsequent operations is to write or append to the node contents.

For EXCLUSIVE_WRITE_CONTENTS, the node contents are locked against opens with read, write or append intent as specified in FIGURE 2. Open and change_intent operations are additionally delayed if there are open node handles to the node with intent to read, write or append to its contents.

APPEND_CONTENTS, EXCLUSIVE_APPEND_CONTENTS:

Open and change_intent operations are delayed if the node or its contents are locked against append operations. The established access right for subsequent operations is to append to the node contents.

For EXCLUSIVE_APPEND_CONTENTS, the node contents are locked against opens with append or write intent as specified in FIGURE 2. Open and change_intent operations are additionally delayed if there are open node handles to the node with intent to append or write to its contents.

READ_ATTRIBUTES, EXCLUSIVE_READ_ATTRIBUTES:

Open and change_intent operations are delayed if the node or its attributes are locked against read operations. The established access right for subsequent operations is to read node attributes.

For EXCLUSIVE_READ_ATTRIBUTES, the node is locked against opens with intent to write attributes as specified in FIGURE 2. Open and change_intent operations are additionally delayed if there are open node handles to the node with intent to write attributes.

WRITE_ATTRIBUTES, EXCLUSIVE_WRITE_ATTRIBUTES:

Open and change_intent operations are delayed if the node or its attributes are locked against write operations. The established access right for subsequent operations is to modify and create node attributes.

For EXCLUSIVE_WRITE_ATTRIBUTES, the node is locked against opens with intent to read, write or append attributes as specified in FIGURE 2. Open and change_intent operations are additionally delayed if there are open node handles to the node with intent to read, write or append attributes.

APPENDS_ATTRIBUTES, EXCLUSIVE_APPEND_ATTRIBUTES:

Open and change_intent operations are delayed if the node or its attributes are locked against append operations. The established access right for subsequent operations is to create node attributes.

For EXCLUSIVE_APPEND_ATTRIBUTES, the node is locked against opens with intent to write or append attributes as specified in FIGURE 2. Open and change_intent operations are additionally delayed if there are open node handles to the node with intent to write or append attributes.

READ_RELATIONSHIPS, EXCLUSIVE_READ_RELATIONSHIPS:

Open and change_intent operations are delayed if the node or its relationships are locked against read operations. The established access right for subsequent operations is to read node relationships, including their attributes.

For EXCLUSIVE_READ_RELATIONSHIPS, the node is locked against opens with intent to write relationships as specified in FIGURE 2. Open and change_intent operations are additionally delayed if there are open node handles to the node with intent to write relationships.

WRITE_RELATIONSHIPS, EXCLUSIVE_WRITE_RELATIONSHIPS:

Open and change_intent operations are delayed if the node or its relationships are locked against write operations. The established access right for subsequent operations is to write or create node relationships, including their attributes.

For EXCLUSIVE_WRITE_RELATIONSHIPS, the node is locked against opens with intent to read, write or append relationships as specified in FIGURE 2. Open and change_intent operations are additionally delayed if there are open node handles to the node with intent to read, or write append relationships.

APPEND_RELATIONSHIPS, EXCLUSIVE_APPEND_RELATIONSHIPS:

Open and change_intent operations are delayed if the node or its relationships are locked against append operations. The established access right for subsequent operations is to create node relationships, including their attributes.

For EXCLUSIVE_APPEND_RELATIONSHIPS, the node is locked against opens with intent to write or append relationships as specified in FIGURE 2. Open and change_intent operations are additionally delayed if there are open node handles to the node with intent to write or append relationships.

CONTROL, EXCLUSIVE_CONTROL:

Open and change_intent operations are delayed if the node or its relationships are locked against write or control operations. The established access right for subsequent operations is to read, write or append access control information.

For EXCLUSIVE_CONTROL, the node is locked against opens to read, write, or append relationships or to read, write, or append access control information as

specified in FIGURE 2. Open and change_intent operations are additionally delayed if there are open node handles to the node with intent to read, write or append relationships or to read, write or append access control information.

EXECUTE: Open and change_intent operations are delayed if the node contents are locked against read operations. The established access right for subsequent operations is the permission to initiate a process taking the node contents as executable image.

Open node handles can block other attempts to open other node handles or to change the intent of other node handles according to the rules demonstrated in FIGURE 2.

	I1 \ I2	NON-EXCLUSIVE														EXCLUSIVE											
		EXIST	R	W	RC	WC	AC	RA	WA	AA	RR	WR	AR	C	EXEC	R	W	RC	WC	AC	RA	WA	AA	RR	WR	AR	C
NON-EXCLUSIVE	EXIST																										
	R																X		X			X			X		X
	W															X	X	X	X	X	X	X	X	X	X	X	X
	RC																X		X								
	WC															X	X	X	X	X							
	AC																X		X	X							
	RA																X										
	WA															X	X										
	AA																X										
	RR																X										X
	WR															X	X								X	X	X
	AR																X								X	X	X
	C															X	X							X	X	X	X
	EXEC															X		X									
EXCLUSIVE	R		X		X			X			X		X				X		X			X			X		X
	W	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X
	RC		X		X												X		X								
	WC	X	X	X	X	X								X		X	X	X	X	X							
	AC		X		X	X											X		X	X							
	RA		X														X										
	WA	X	X													X	X										
	AA		X														X										
	RR		X										X				X										X
	WR	X	X								X	X	X			X	X								X	X	X
	AR		X								X	X	X				X								X	X	X
	C	X	X							X	X	X	X			X	X							X	X	X	X

X = Open with intent I2 is blocked if there are open handles opened with intent I1.

Exist = EXISTENCE   R = READ   W = WRITE
RC = READ_CONTENTS   WC = WRITE_CONTENTS   AC = APPEND_CONTENTS
RA = READ_ATTRIBUTES   WA = WRITE_ATTRIBUTES   AA = APPEND_ATTRIBUTES
RR = READ_RELATIONSHIPS   WR = WRITE_ATTRIBUTES   AR = APPEND_RELATIONSHIPS
C = CONTROL   Exec = EXECUTE

Figure 2. Matrix of access synchronization constraints

5.1.2.1. Opening a node handle

```
procedure OPEN(NODE:       in out NODE_TYPE;
               NAME:       in     NAME_STRING;
               INTENT:     in     INTENTION :=
                                    (1 => READ);
               TIME_LIMIT: in     DURATION := NO_DELAY);

procedure OPEN(NODE:       in out NODE_TYPE;
               BASE:       in     NODE_TYPE;
               KEY:        in     RELATIONSHIP_KEY;
               RELATION:   in     RELATION_NAME:=
                                    DEFAULT_RELATION;
               INTENT:     in     INTENTION := (1 => READ);
               TIME_LIMIT: in     DURATION := NO_DELAY);
```

Purpose:

These procedures return an open node handle in NODE to the node identified by the pathname NAME or BASE/KEY/RELATION, respectively. The INTENT parameter determines the access rights available for subsequent uses of the node handle; it also establishes access synchronization with other users of the node. The TIME_LIMIT parameter allows the specification of a time limit for the delay imposed on OPEN by the existence of locks on the node. A delayed OPEN call completes after the node is unlocked or the specified time limit has elapsed. In the latter case, the exception LOCK_ERROR is raised.

Parameters:

NODE — is a node handle, initially closed, to be opened to the identified node.

NAME — is the pathname identifying the node to be opened.

BASE — is an open node handle to a base node for node identification.

KEY — is the relationship key for node identification.

RELATION — is the relation name for node identification.

INTENT — is the intent of subsequent operations on the node; the actual parameter takes the form of an array aggregate.

TIME_LIMIT — is a value of type DURATION, specifying a time limit for the delay on waiting for the unlocking of a node in accordance with the desired INTENT.

Exceptions:

NAME_ERROR
is raised if the pathname specified by NAME is syntactically illegal or if any traversed node in the path specified by name is unobtainable, inaccessible or non-existent or if the relationship specified by RELATION and KEY or by the last path element of NAME does not exist. NAME_ERROR is also raised if the node to which a handle is to be opened is inaccessible or unobtainable and the given INTENT includes any intent other than EXISTENCE.

USE_ERROR is raised if the specified INTENT is an empty array.

STATUS_ERROR
is raised if the node handle NODE is already open prior to the call on OPEN or if BASE is not an open node handle.

LOCK_ERROR
is raised if the OPEN operation is delayed beyond the specified time limit due to the existence of locks in conflict with the specified INTENT. This includes any delays caused by locks on nodes traversed on the path specified by the pathname NAME or locks on the node identified by BASE, preventing the reading of relationships emanating from these nodes.

INTENT_VIOLATION
is raised if BASE was not opened with an intent establishing the right to read relationships.

ACCESS_VIOLATION
is raised if the current process' discretionary access control rights are insufficient to traverse the path specified by NAME by BASE, KEY and RELATION or to obtain access to the node consistent with the specified INTENT. ACCESS_VIOLATION is raised only if the conditions for NAME_ERROR are not present.

SECURITY_VIOLATION
is raised if the attempt to obtain access to the node with the specified INTENT represents a violation of mandatory access controls for the CAIS. SECURITY_VIOLATION is raised only if the conditions for other exceptions are not present.

Notes:

An open node handle acts as if the handle forms an unnamed temporary secondary relationship to the node; this means that, if the node identified by the open node handle is renamed (potentially by another process), the open node handle tracks the renamed node.

It is possible to open a node handle to an unobtainable node or to an inaccessible node. The latter is consistent with the fact that the existence of a relationship emanating from an accessible node to which the user has READ_RELATIONSHIPS rights cannot be hidden from the user.

5.1.2.2. Closing a node handle

```
procedure CLOSE(NODE: in out NODE_TYPE);
```

Purpose:

This procedure severs any association between the node handle NODE and the node and releases any associated lock on the node imposed by the intent of the node handle NODE. Closing an already closed node handle has no effect.

Parameter:

NODE	is a node handle, initially open, to be closed.

Exceptions:

none

Notes:

A NODE_TYPE variable must be closed before another OPEN can be called using the same NODE_TYPE variable as an actual parameter to the formal NODE parameter of OPEN.

5.1.2.3. Changing the intention regarding node handle usage

```
procedure CHANGE_INTENT(NODE:       in out NODE_TYPE;
                        INTENT:     in     INTENTION;
                        TIME_LIMIT: in     DURATION:=
                                             NO_DELAY);
```

Purpose:

This procedure changes the intention regarding use of the node handle NODE. It is semantically equivalent to closing the node handle and reopening the node handle to the same node with the INTENT and TIME_LIMIT parameters of CHANGE_INTENT, except that CHANGE_INTENT guarantees to return an open node handle that refers to the same node as the node handle input in NODE (see the issue explained in the note below).

Parameter:

NODE
: is an open node handle

INTENT
: is the intent of subsequent operations on the node; the actual parameter takes the form of an array aggregate.

TIME_LIMIT
: is a value of type DURATION, specifying a time limit for the delay on waiting for the unlocking of a node in accordance with the desired INTENT.

Exceptions:

NAME_ERROR
: is raised if the node handle NODE refers to an unobtainable node and INTENT contains any intent specification other than EXISTENCE.

STATUS_ERROR
: is raised if the node handle NODE is not an open node handle.

LOCK_ERROR
: is raised if the operation is delayed beyond the specified time limit due to the existence of locks on the node in conflict with the specified INTENT.

ACCESS_VIOLATION
: is raised if the current process' discretionary access control rights are insufficient to obtain access to the node consistent with the specified INTENT. ACCESS_VIOLATION is raised only if the condition for NAME_ERROR is not present.

SECURITY_VIOLATION
: is raised if the attempt to obtain access consistent with the intention INTENT to the node specified by NODE represents a violation of mandatory access controls for

the CAIS. SECURITY_VIOLATION is raised only if the conditions for other exceptions are not present.

Notes:

Use of the sequence of a CLOSE and an OPEN operation instead of a CHANGE_INTENT operation cannot guarantee that the same node is opened, since relationships, and therefore the node identification, may have changed since the previous OPEN on the node.

5.1.2.4. Examining the open status of a node handle

```
function IS_OPEN(NODE: in NODE_TYPE)
        return BOOLEAN;
```

Purpose:

This function returns TRUE if the node handle NODE is open; otherwise, it returns FALSE.

Parameter:

NODE is a node handle.

Exceptions:

None.

5.1.2.5. Querying the intention of a node handle

```
function INTENT_OF(NODE: in NODE_TYPE)
        return INTENTION;
```

Purpose:

This function returns the intent with which the node handle NODE is open.

Parameter:

NODE is an open node handle.

Exception:

STATUS_ERROR
is raised if the node handle NODE is not open.

5.1.2.6. Querying the kind of a node

```
function KIND(NODE: in NODE_TYPE)
        return NODE_KIND;
```

Purpose:

This function returns the kind of a node, either FILE, PROCESS or STRUCTURAL.

Parameter:

NODE is an open node handle.

Exceptions:

STATUS_ERROR
is raised if the node handle NODE is not open.

5.1.2.7. Obtaining the unique primary pathname

```
function PRIMARY_NAME(NODE: in NODE_TYPE)
    return NAME_STRING;
```

Purpose:

This function returns the unique primary name of the node identified by NODE.

Parameter:

NODE is an open node handle identifying the node.

Exceptions:

NAME_ERROR
is raised if any node traversed on the primary path to the node is inaccessible.

STATUS_ERROR
is raised if the node handle NODE is not open.

LOCK_ERROR
is raised if access consistent with intent READ_RELATIONSHIPS to any node traversed on the primary path cannot be obtained due to an existing lock on the node.

INTENT_VIOLATION
is raised if NODE was not opened with an intent establishing the right to read relationships.

ACCESS_VIOLATION
is raised if the current process' discretionary access control rights are insufficient to traverse the node's primary path. ACCESS_VIOLATION is raised only if the conditions for NAME_ERROR are not present.

5.1.2.8. Obtaining the relationship key of a primary relationship

```
function PRIMARY_KEY(NODE: in NODE_TYPE)
    return RELATIONSHIP_KEY;
```

Purpose:

This function returns the relationship key of the last path element of the unique primary pathname of the node.

Parameter:

NODE is an open node handle identifying the node.

Exceptions:

NAME_ERROR
is raised if the parent node of the node identified by NODE is inaccessible.

STATUS_ERROR
is raised if the node handle NODE is not open.

LOCK_ERROR
is raised if the parent node is locked against reading relationships.

INTENT_VIOLATION
is raised if the node handle NODE was not opened with an intent establishing the right to read relationships.

ACCESS_VIOLATION
is raised if the current process' discretionary access control rights are insufficient to obtain access to the node's parent consistent with intent READ_RELATIONSHIP. ACCESS_VIOLATION is raised only if the conditions for NAME_ERROR are not present.

5.1.2.9. Obtaining the relation name of a primary relationship

```
function PRIMARY_RELATION(NODE: in NODE_TYPE)
         return RELATION_NAME;
```

Purpose:

This function returns the relation name of the last path element of the unique primary pathname of the node.

Parameter:

NODE is an open node handle identifying the node.

Exceptions:

NAME_ERROR
is raised if the parent node of the node identified by NODE is inaccessible.

STATUS_ERROR
is raised if the node handle NODE is not open.

LOCK_ERROR
is raised if the parent node is locked against reading relationships.

INTENT_VIOLATION
is raised if NODE was not opened with an intent establishing the right to read relationships.

ACCESS_VIOLATION
is raised if the current process' discretionary access control rights are insufficient to obtain access to the node's parent consistent with intent to READ_RELATIONSHIPS. ACCESS_VIOLATION is raised only if the conditions for NAME_ERROR are not present.

5.1.2.10. Obtaining the relationship key of the last relationship traversed

```
function PATH_KEY(NODE: in NODE_TYPE)
    return RELATIONSHIP_KEY;
```

Purpose:

This function returns the relationship key of the relationship corresponding to the last path element of the pathname used in opening this node handle. Since a path element is a string, the relationship key is returned even if the relationship has been deleted.

Parameter:

NODE — is an open node handle.

Exceptions:

STATUS_ERROR
: is raised if the node handle NODE is not open.

5.1.2.11. Obtaining the relation name of the last relationship traversed

```
function PATH_RELATION(NODE: in NODE_TYPE)
    return RELATION_NAME;
```

Purpose:

This function returns the relation name of the relationship corresponding to the last path element of the pathname used in opening this node handle. The relation name is returned even if the relationship has been deleted.

Parameter:

NODE — is an open node handle.

Exceptions:

STATUS_ERROR
: is raised if the node handle NODE is not open.

5.1.2.12. Obtaining a partial pathname

```
function BASE_PATH(NAME: in NAME_STRING)
    return NAME_STRING;
```

Purpose:

This function returns the pathname obtained by deleting the last path element from NAME. It does not establish whether the pathname identifies an existing node; only the syntactic properties of the pathname are examined. This function also checks the syntactic legality of the pathname NAME.

Parameters:

NAME — is a pathname (not necessarily identifying a node).

Exceptions:

NAME_ERROR
is raised if NAME is a syntactically illegal pathname.

5.1.2.13. Obtaining the name of the last relationship in a pathname

```
function LAST_RELATION(NAME: in NAME_STRING)
        return RELATION_NAME;
```

Purpose:

This function returns the name of the relation of the last path element of the pathname NAME. It does not establish whether the pathname identifies an existing node; only the syntactic properties of the pathname are examined. This function also checks the syntactic legality of the pathname NAME.

Parameters:

NAME is a pathname (not necessarily identifying a node).

Exceptions:

NAME_ERROR
is raised if NAME is a syntactically illegal pathname.

5.1.2.14. Obtaining the key of the last relationship in a pathname

```
function LAST_KEY(NAME: in NAME_STRING)
        return RELATIONSHIP_KEY;
```

Purpose:

This function returns the relationship key of the last path element of the pathname NAME. It does not establish whether the pathname identifies an existing node; only the syntactic properties of the pathname are examined. This function checks the syntactic legality of the pathname NAME.

Parameters:

NAME is a pathname (not necessarily identifying a node).

Exceptions:

NAME_ERROR
is raised if NAME is a syntactically illegal pathname.

5.1.2.15. Querying the existence of a node

```
function IS_OBTAINABLE(NODE: in NODE_TYPE)
        return BOOLEAN;
```

Purpose:

This function returns FALSE if the node identified by NODE is unobtainable or inaccessible. It returns TRUE otherwise.

Parameters:

NODE is an open node handle identifying the node.

Exceptions:

STATUS_ERROR
is raised if NODE is not an open node handle.

Additional Interfaces:

```
function IS_OBTAINABLE(NAME: in NAME_STRING)
        return BOOLEAN
is
    NODE:   NODE_TYPE;
    RESULT: BOOLEAN;
begin
    OPEN(NODE, NAME, (1=>EXISTENCE));
    RESULT := IS_OBTAINABLE(NODE);
    CLOSE(NODE);
    return RESULT;
exception
    when others => return FALSE;
end IS_OBTAINABLE;

function IS_OBTAINABLE(BASE:     in NODE_TYPE;
                       KEY:      in RELATIONSHIP_KEY;
                       RELATION: in RELATION_NAME := DEFAULT_RELATION)
        return BOOLEAN
is
    NODE:   NODE_TYPE;
    RESULT: BOOLEAN;
begin
    OPEN(NODE, BASE, KEY, RELATION, (1=>EXISTENCE));
    RESULT := IS_OBTAINABLE(NODE);
    CLOSE(NODE);
    return RESULT;
exception
    when others => return FALSE;
end IS_OBTAINABLE;
```

Notes:

OBTAINABLE can be used to determine whether a node identified via a secondary relationship has been made unobtainable by a DELETE operation or is inaccessible to the current process (see Note in Section 5.1.2.3).

5.1.2.16. Querying sameness

```
function IS_SAME(NODE1: in NODE_TYPE;
                 NODE2: in NODE_TYPE)
        return BOOLEAN;
```

Purpose:

This function returns TRUE if the nodes identified by its arguments are the same node; otherwise, it returns FALSE.

Parameters:

NODE1 is an open node handle to a node.

NODE2 is an open node handle to a node.

Exceptions:

STATUS_ERROR
is raised if at least one of the node handles, NODE1 and NODE2, is not open.

Additional Interface:

```
function IS_SAME(NAME1: in NAME_STRING;
                 NAME2: in NAME_STRING)
    return BOOLEAN
is
    NODE1, NODE2: NODE_TYPE;
    RESULT:       BOOLEAN;
begin
    OPEN(NODE1, NAME1, (1=>EXISTENCE));
    begin
        OPEN(NODE2, NAME2, (1=>EXISTENCE));
    exception
        when others =>
            CLOSE(NODE1);
            raise;
    end;
    RESULT := IS_SAME(NODE1, NODE2);
    CLOSE(NODE1);
    CLOSE(NODE2);
    return RESULT;
end IS_SAME;
```

Notes:

Sameness is not to be confused with equality of attribute values, relationships and contents of nodes, which is a necessary but not a sufficient criterion for sameness.

5.1.2.17. Obtaining an open node handle to the parent node

```
procedure GET_PARENT(PARENT:     in out NODE_TYPE;
                     NODE:       in     NODE_TYPE;
                     INTENT:     in     INTENTION := (1=>READ);
                     TIME_LIMIT: in     DURATION := NO_DELAY);
```

Purpose:

This procedure returns an open node handle in PARENT to the parent node of the node identified by the open node handle NODE. The intent under which the node handle PARENT is opened is specified by INTENT. A call on GET_PARENT is equivalent to a call OPEN(PARENT, NODE, "", PARENT, INTENT, TIME_LIMIT).

Parameters:

PARENT is a node handle, initially closed, to be opened to the parent node.

NODE is an open node handle identifying the node.

INTENT is the intent of subsequent operations on the node handle PARENT.

TIME_LIMIT is a value of type DURATION, specifying a time limit for the delay on waiting for the unlocking of the parent node in accordance with the desired INTENT.

Exceptions:

NAME_ERROR
is raised if the node identified by NODE is a top-level node or if its parent node is inaccessible.

USE_ERROR is raised if the specified INTENT is an empty array.

STATUS_ERROR
is raised if the node handle PARENT is open prior to the call or if the node handle NODE is not open.

LOCK_ERROR
is raised if the opening of the parent node is delayed beyond the specified TIME_LIMIT due to the existence of locks in conflict with the specified INTENT.

INTENT_VIOLATION
is raised if NODE was not opened with an intent establishing the right to read relationships.

ACCESS_VIOLATION
is raised if the current process' discretionary access control rights are insufficient to obtain access to the parent node with the specified INTENT. ACCESS_VIOLATION is raised only if the conditions for NAME_ERROR are not present.

SECURITY_VIOLATION
is raised if the attempt to gain with the specified INTENT access to the parent node represents a violation of mandatory access controls for the CAIS. SECURITY_VIOLATION is raised only if the conditions for other exceptions are not present.

5.1.2.18. Copying a node

```
procedure COPY_NODE(FROM:        in NODE_TYPE;
                    TO_BASE:     in NODE_TYPE;
                    TO_KEY:      in RELATIONSHIP_KEY;
                    TO_RELATION: in RELATION_NAME
                                    :=DEFAULT_RELATION);
```

Purpose:

This procedure copies a file or structural node that does not have emanating primary relationships. The node copied is identified by the open node handle FROM and is copied to a newly created node. The new node is identified by the combination of the TO_BASE, TO_KEY and TO_RELATION parameters. The newly created node is of the same kind as the node identified by FROM. If the node is a file node, its contents are also copied, i.e., a new copied file is created. Any secondary relationships emanating from the original node, excepting the relationship of the predefined relation PARENT (which is appropriately adjusted), are recreated in the copy. If the target of the original node's relationship is the node itself, then the copy has an analogous relationship to itself. Any other secondary relationship whose target is the original node is unaffected. All attributes of the FROM node are also copied. Regardless of any locks on the node identified by FROM, the newly created node is unlocked.

Parameters:

FROM is an open node handle to the node to be copied.

TO_BASE is an open node handle to the base node for identification of the node to be created.

TO_KEY is a relationship key for the identification of the node to be created.

TO_RELATION
is a relation name for the identification of the node to be created.

Exceptions:

NAME_ERROR
is raised if the new node identification is illegal or if a node already exists with the identification given for the new node.

USE_ERROR is raised if the original node is not a file or structural node or if any primary relationships emanate from the original node. USE_ERROR is also raised if TO_RELATION is the name of a predefined relation that cannot be modified or created by the user.

STATUS_ERROR
is raised if the node handles FROM and TO_BASE are not both open.

INTENT_VIOLATION
is raised if FROM was not opened with an intent establishing the right to read contents, attributes, and relationships or if TO_BASE was not opened with an intent establishing the right to append relationships. INTENT_VIOLATION is not raised if the conditions for NAME_ERROR are present.

SECURITY_VIOLATION
is raised if the operation represents a violation of mandatory access controls and the conditions for other exceptions are not present.

Additional Interface:

```
procedure COPY_NODE(FROM: in NODE_TYPE;
                    TO:   in NAME_STRING)
is
    TO_BASE: NODE_TYPE;
begin
    OPEN(TO_BASE, BASE_PATH(TO), (1=>APPEND_RELATIONSHIPS));
    COPY_NODE(FROM, TO_BASE, LAST_KEY(TO), LAST_RELATION(TO));
    CLOSE(TO_BASE);
exception
    when others =>
        CLOSE(TO_BASE);
        raise;
end COPY_NODE;
```

5.1.2.19. Copying trees

```
procedure COPY_TREE(FROM:        in NODE_TYPE;
                    TO_BASE:     in NODE_TYPE;
                    TO_KEY:      in RELATIONSHIP_KEY;
                    TO_RELATION: in RELATION_NAME
                                   :=DEFAULT_RELATION);
```

Purpose:

This procedure copies a tree of file or structural nodes formed by primary relationships emanating from the node identified by the open node handle FROM. Primary relationships are recreated between corresponding copied nodes. The root node of the newly created tree corresponding to the FROM node is the node identified by the combination of the TO_BASE, TO_KEY and TO_RELATION parameters. If an exception is raised by the procedure, none of the nodes are copied. Secondary relationships, attributes, and node contents are copied as described for COPY_NODE with the following additional rules: secondary relationships between two nodes which both are copied are recreated between the two copies. Secondary relationships emanating from a node which is copied, but which refer to nodes outside the tree being copied, are copied so that they emanate from the copy, but still refer to the original target node. Secondary relationships emanating from a node which is not copied, but which refer to nodes inside the tree being copied, are unaffected. If the node identified by TO_BASE is part of the tree to be copied, then the copy of the node identified by FROM will not be copied recursively.

Parameters:

FROM is an open node handle to the root node of the tree to be copied.

TO_BASE is an open node handle to the base node for identification of the node to be created as root of the new tree.

TO_KEY is a relationship key for the identification of the node to be created as root of the new tree.

TO_RELATION
is a relation name for the identification of the node to be created as root of the new tree.

Exceptions:

NAME_ERROR
is raised if the new node identification is illegal or if a node already exists with the identification given for the new node to be created as a copy of the node identified by FROM.

STATUS_ERROR
is raised if the node handles FROM and TO_BASE are not both open.

USE_ERROR is raised if the original node is not a file or structural node. USE_ERROR is also raised if TO_RELATION is the name of a predefined relation that cannot be modified or created by the user.

LOCK_ERROR
is raised if any node to be copied except the node identified by FROM, is locked against read access to attributes, relationships or contents.

INTENT_VIOLATION
is raised if FROM is not open with an intent establishing the right to read node contents, attributes and relationships or if TO_BASE is not open with an intent establishing the right to append relationships. INTENT_VIOLATION is only raised if the conditions for NAME_ERROR are not present.

ACCESS_VIOLATION
is raised if the current process' discretionary access control rights are insufficient to obtain access to each node to be copied with intent READ. ACCESS_VIOLATION is not raised if conditions for NAME_ERROR are present.

SECURITY_VIOLATION
is raised if the operation represents a violation of mandatory access controls and the conditions for other exceptions are not present.

Additional Interface:

```
procedure COPY_TREE(FROM: in NODE_TYPE;
                    TO:   in NAME_STRING)
is
    TO_BASE: NODE_TYPE;
begin
    OPEN(TO_BASE, BASE_PATH(TO), (1=>APPEND_RELATIONSHIPS));
    COPY_TREE(FROM, TO_BASE, LAST_KEY(TO), LAST_RELATION(TO));
    CLOSE(TO_BASE);
exception
    when others =>
        CLOSE(TO_BASE);
        raise;
end COPY_TREE;
```

5.1.2.20. Renaming the primary relationship of a node

```
procedure RENAME(NODE:         in NODE_TYPE;
                 NEW_BASE:     in NODE_TYPE;
                 NEW_KEY:      in RELATIONSHIP_KEY;
                 NEW_RELATION: in RELATION_NAME
                                  :=DEFAULT_RELATION);
```

Purpose:

This procedure renames a file or structural node. It deletes the primary relationship to the node identified by NODE and installs a new primary relationship to the node, emanating from the node identified by NEW_BASE, with key and relation name given by the NEW_KEY and NEW_RELATION parameters. The parent relationship is changed accordingly. This changes the unique primary pathname of the node. Existing secondary relationships with the renamed node as target track the renaming, i.e., they have the renamed node as target.

Parameters:

NODE — is an open node handle to the node to be renamed.

NEW_BASE — is an open node handle to the base node from which the new primary relationship to the renamed node emanates.

NEW_KEY — is a relationship key for the new primary relationship.

NEW_RELATION
is a relation name for the new primary relationship.

Exceptions:

NAME_ERROR
is raised if the new node identification is illegal or if a node already exists with the identification given for the new node.

USE_ERROR is raised if the node identified by NODE is not a file or structural node or if the renaming cannot be accomplished while still maintaining acircularity of primary relationships (e.g., if the new parent node would be the renamed node). USE_ERROR is also raised if NEW_RELATION is the name of a predefined relation that cannot be modified or created by the user or if the primary relationship to be deleted belongs to a predefined relation that cannot be modified by the user.

STATUS_ERROR
is raised if the node handles NODE and NEW_BASE are not open.

LOCK_ERROR
is raised if access, with intent WRITE_RELATIONSHIPS, to the parent of the node to be deleted cannot be obtained due to an existing lock on the node.

INTENT_VIOLATION
is raised if NODE was not opened with an intent establishing the right to write relationships or if NEW_BASE was not opened with an intent establishing the right to append relationships.

ACCESS_VIOLATION
is raised if the current process does not have sufficient discretionary access control rights to obtain access to the parent of the node to be renamed with intent WRITE_RELATIONSHIPS and the conditions for NAME_ERROR are not present.

SECURITY_VIOLATION
is raised if the operation represents a violation of mandatory access controls. SECURITY_VIOLATION is raised only if the conditions for other exceptions are not present.

Additional Interface:

```
procedure RENAME(NODE:     in NODE_TYPE;
                 NEW_NAME: in NAME_STRING)
is
   NEW_BASE: NODE_TYPE;
begin
   OPEN(NEW_BASE, BASE_PATH(NEW_NAME), (1=>APPEND_RELATIONSHIPS));
   RENAME (NODE, NEW_BASE, LAST_KEY(NEW_NAME),
                              LAST_RELATION(NEW_NAME));
   CLOSE(NEW_BASE);
exception
   when others =>
      CLOSE(NEW_BASE);
```

```
        raise;
    end RENAME;
```

Notes:

Open node handles from existing processes track the renamed node.

5.1.2.21. Deleting the primary relationship to a node

```
procedure DELETE_NODE(NODE: in out NODE_TYPE);
```

Purpose:

This procedure deletes the primary relationship to a node identified by NODE. The node becomes unobtainable. The node handle NODE is closed. If the node is a process node and the process is not yet TERMINATED (see Section 5.2), DELETE_NODE aborts the process.

Parameters:

NODE is an open node handle to the node which is the target of the primary relationship to be deleted.

Exceptions:

NAME_ERROR
is raised if the parent node of the node identified by NODE is inaccessible.

USE_ERROR is raised if any primary relationships emanate from the node.

STATUS_ERROR
is raised if the node handle NODE is not open prior to the call.

LOCK_ERROR
is raised if access, with intent WRITE_RELATIONSHIPS, to the parent of the node to be deleted cannot be obtained due to an existing lock on the node.

INTENT_VIOLATION
is raised if the node handle NODE was not opened with an intent including EXCLUSIVE_WRITE and READ_RELATIONSHIPS.

ACCESS_VIOLATION
is raised if the current process does not have sufficient discretionary access control rights to obtain access to the parent of the node to be deleted with intent WRITE_RELATIONSHIPS and the conditions for NAME_ERROR are not present.

SECURITY_VIOLATION
is raised if the operation represents a violation of mandatory access controls. SECURITY_VIOLATION is raised only if the conditions for other exceptions are not present.

Additional Interface:

```
procedure DELETE_NODE(NAME: in NAME_STRING)
is
```

```
        NODE: NODE_TYPE;
    begin
        OPEN(NODE, NAME, (EXCLUSIVE_WRITE,READ_RELATIONSHIPS));
        DELETE_NODE(NODE);
    exception
        when others =>
            CLOSE(NODE);
            raise;
    end DELETE_NODE;
```

Notes:

The DELETE_NODE operations cannot be used to delete more than one primary relation node in a single operation. It is left to an implementation decision whether and when nodes whose primary relationships have been broken are actually removed. However, secondary relationships to such nodes must remain until they are explicitly deleted using the UNLINK procedures.

5.1.2.22. Deleting the primary relationships of a tree

```
procedure DELETE_TREE(NODE: in out NODE_TYPE);
```

Purpose:

This procedure effectively performs the DELETE_NODE operation for a specified node and recursively applies DELETE_TREE to all nodes reachable by a unique primary pathname from the designated node. The nodes whose primary relationships are to be deleted are opened with intent EXCLUSIVE_WRITE, thus locking them for other operations. The order in which the deletions of primary relationships is performed is not specified. If the DELETE_TREE operation raises an exception, none of the primary relationships is deleted.

Parameters:

NODE — is an open node handle to the node at the root of the tree whose primary relationships are to be deleted.

Exceptions:

NAME_ERROR
is raised if the parent node of the node identified by NODE or any of the target nodes of primary relationships to be deleted are inaccessible.

USE_ERROR is raised if the primary relationship to the node identified by NODE belongs to a predefined relation that cannot be modified by the user.

STATUS_ERROR
is raised if the node handle NODE is not open prior to the call.

LOCK_ERROR
is raised if a node handle to the parent of the node specified by NODE cannot be opened with intent WRITE_RELATIONSHIPS or if a node handle identifying any node whose unique primary path traverses the node identified by NODE cannot be opened with intent EXCLUSIVE_WRITE.

INTENT_VIOLATION
is raised if the node handle NODE was not opened with an intent including EXCLUSIVE_WRITE and READ_RELATIONSHIPS.

ACCESS_VIOLATION
is raised if the current process does not have sufficient discretionary access control rights to obtain access to the parent of the node specified by NODE with intent WRITE_RELATIONSHIPS or to obtain access to any target node of a primary relationship to be deleted with intent EXCLUSIVE_WRITE and the conditions for NAME_ERROR are not present.

SECURITY_VIOLATION
is raised if the operation represents a violation of mandatory access controls. SECURITY_VIOLATION is raised only if the conditions for other exceptions are not present.

Additional Interface:

```
procedure DELETE_TREE(NAME: in NAME_STRING)
is
    NODE: NODE_TYPE;
begin
    OPEN(NODE, NAME, (EXCLUSIVE_WRITE,READ_RELATIONSHIPS));
    DELETE_TREE(NODE);
exception
    when others =>
        CLOSE(NODE);
        raise;
end DELETE_TREE;
```

Notes:

This operation can be used to delete more than one primary relationship in a single operation.

5.1.2.23. Creating secondary relationships

```
procedure LINK(NODE:          in NODE_TYPE;
               NEW_BASE:      in NODE_TYPE;
               NEW_KEY:       in RELATIONSHIP_KEY;
               NEW_RELATION:  in RELATION_NAME
                                 :=DEFAULT_RELATION);
```

Purpose:

This procedure creates a secondary relationship between two existing nodes. The procedure takes a node handle NODE on the target node, a node handle NEW_BASE on the source node, and an explicit key NEW_KEY and relation name NEW_RELATION for the relationship to be established from NEW_BASE to NODE.

Parameters:

NODE is an open node handle to the node to which the new secondary relationship points.

NEW_BASE is an open node handle to the base node from which the new secondary relationship to the node emanates.

NEW_KEY is the relationship key for the new secondary relationship.

NEW_RELATION
is the relation name for the new secondary relationship.

Exceptions:

NAME_ERROR
: is raised if the relationship key or the relation name are illegal or if a node already exists with the identification given by NEW_BASE, NEW_KEY, and NEW_RELATION.

USE_ERROR
: is raised if NEW_RELATION is the name of a predefined relation that cannot be modified or created by the user.

STATUS_ERROR
: is raised if the node handles NODE and NEW_BASE are not open.

INTENT_VIOLATION
: is raised if NEW_BASE was not opened with an intent establishing the right to append relationships.

SECURITY_VIOLATION
: is raised if the operation represents a violation of mandatory access controls. SECURITY_VIOLATION is raised only if the conditions for other exceptions are not present.

Additional Interface:

```
procedure LINK(NODE:     in NODE_TYPE;
               NEW_NAME: in NAME_STRING)
is
    NEW_BASE: NODE_TYPE;
begin
    OPEN(NEW_BASE, BASE_PATH(NEW_NAME), (1=>APPEND_RELATIONSHIPS));
    LINK(NODE, NEW_BASE, LAST_KEY(NEW_NAME),
                                   LAST_RELATION(NEW_NAME));
    CLOSE(NEW_BASE);
exception
    when others =>
        CLOSE(NEW_BASE);
        raise;
end LINK;
```

5.1.2.24. Deleting secondary relationships

```
procedure UNLINK(BASE:     in NODE_TYPE;
                 KEY:      in RELATIONSHIP_KEY;
                 RELATION: in RELATION_NAME
                              :=DEFAULT_RELATION);
```

Purpose:

This procedure deletes a secondary relationship identified by the BASE, KEY and RELATION parameters.

Parameters:

BASE
: is an open node handle to the node from which the relationship emanates which is to be deleted.

KEY
: is the relationship key of the relationship to be deleted.

RELATION is the relation name of the relationship to be deleted.

Exceptions:

NAME_ERROR
is raised if the relationship identified by BASE, KEY and RELATION does not exist.

USE_ERROR is raised if the specified relationship is a primary relationship. USE_ERROR is also raised if RELATION is the name of a predefined relation that cannot be modified or created by the user.

STATUS_ERROR
is raised if the BASE is not an open node handle.

INTENT_VIOLATION
is raised if BASE was not opened with an intent establishing the right to write relationships.

SECURITY_VIOLATION
is raised if the operation represents a violation of mandatory access controls. SECURITY_VIOLATION is raised only if the conditions for other exceptions are not present.

Additional Interface:

```
procedure UNLINK(NAME: in NAME_STRING)
is
    BASE: NODE_TYPE;
begin
    OPEN(BASE, BASE_PATH(NAME), (1=>WRITE_RELATIONSHIPS));
    UNLINK(BASE, LAST_KEY(NAME), LAST_RELATION(NAME));
    CLOSE(BASE);
exception
    when others =>
        CLOSE(BASE);
        raise;
end UNLINK;
```

Notes:

UNLINK can be used to delete secondary relationships to nodes that have become unobtainable.

5.1.2.25. Node iteration types and subtypes

```
type    NODE_ITERATOR is limited private;
subtype RELATIONSHIP_KEY_PATTERN is RELATIONSHIP_KEY;
subtype RELATION_NAME_PATTERN is RELATION_NAME;
```

These types are used in the following interfaces for iterating over a set of nodes. RELATIONSHIP_KEY_PATTERN and RELATION_NAME_PATTERN follow the syntax of relationship keys and relation names, except that '?' will match any single character and '*' will match any string of characters. NODE_ITERATOR is a private type assumed to contain the bookkeeping information necessary for the implementation of the MORE and GET_NEXT functions. The nodes are returned by GET_NEXT in ASCII lexicographical order by relation name and then by

relationship key. The effect on existing iterators of creation or deletion of relationships is implementation-defined.

5.1.2.26. Creating an iterator over nodes

```
procedure ITERATE(ITERATOR:       out NODE_ITERATOR;
                  NODE:           in  NODE_TYPE;
                  KIND:           in  NODE_KIND;
                  KEY:            in  RELATIONSHIP_KEY_PATTERN := "*";
                  RELATION:       in  RELATION_NAME_PATTERN
                                    := DEFAULT_RELATION;
                  PRIMARY_ONLY:   in  BOOLEAN := TRUE);
```

Purpose:

This procedure establishes a node iterator ITERATOR over the set of nodes that are the targets of relationships emanating from a given node identified by NODE and matching the specified KEY and RELATION patterns. Nodes that are of a different kind than the KIND specified are omitted by subsequent calls to GET_NEXT using the resulting ITERATOR. If PRIMARY_ONLY is true, then the iterator will be based on only primary relationships.

Parameters:

ITERATOR is the node iterator returned.

NODE is an open node handle to a node whose relationships form the basis for constructing the iterator.

KIND is the kind of nodes on which the iterator is based.

KEY is the pattern for the relationship keys on which the iterator is based.

RELATION is the pattern for the relation names on which the iterator is based.

PRIMARY_ONLY
is a boolean; if TRUE, the iterator will be based on only primary relationships; if FALSE,the iterator will be based on all relationships satisfying the patterns.

Exceptions:

USE_ERROR is raised if the pattern given in KEY or RELATION is syntactically illegal.

STATUS_ERROR
is raised if NODE is not an open node handle.

INTENT_VIOLATION
is raised if NODE was not opened with an intent establishing the right to read relationships.

Additional Interface:

```
procedure ITERATE(ITERATOR:       out NODE_ITERATOR;
                  NAME:           in  NAME_STRING;
                  KIND:           in  NODE_KIND;
                  KEY:            in  RELATIONSHIP_KEY_PATTERN := "*";
```

```
                    RELATION:     in  RELATION_NAME_PATTERN
                                  := DEFAULT_RELATION;
                    PRIMARY_ONLY: in  BOOLEAN := TRUE)
is
    NODE: NODE_TYPE;
begin
    OPEN(NODE, NAME, (1=>READ_RELATIONSHIPS));
    ITERATE(ITERATOR, NODE, KIND, KEY, RELATION, PRIMARY_ONLY);
    CLOSE(NODE);
exception
    when others =>
        CLOSE(NODE);
        raise;
end ITERATE;
```

Notes:

The functions PATH_KEY and PATH_RELATION may be used to determine the relationship which caused the node to be included in the iteration. The iteration interfaces can be used to determine relationships to inaccessible or unobtainable nodes.

5.1.2.27. Determining iteration status

```
function MORE (ITERATOR: in  NODE_ITERATOR)
         return  BOOLEAN;
```

Purpose:

The function MORE returns FALSE if all nodes contained in the node iterator have been retrieved with the GET_NEXT procedure; otherwise it returns TRUE.

Parameters:

ITERATOR   is a node iterator previously set by the procedure ITERATE.

Exceptions:

USE_ERROR is raised if the ITERATOR has not been previously set by the procedure ITERATE.

5.1.2.28. Getting the next node in an iteration

```
procedure GET_NEXT(ITERATOR:   in out  NODE_ITERATOR;
                   NEXT_NODE:  in out  NODE_TYPE;
                   INTENT:     in      INTENTION := (1=>EXISTENCE);
                   TIME_LIMIT: in      DURATION := NO_DELAY);
```

Purpose:

The procedure GET_NEXT returns an open node handle to the next node in the parameter NEXT_NODE; the intent under which the node handle is opened is specified by the INTENT parameter. If NEXT_NODE is open prior to the call to GET_NEXT, it is closed prior to being opened to the next node. A time limit can be specified for the maximum delay permitted if the node to be opened is locked against access with the specified INTENT.

Parameters:

ITERATOR   is a node iterator previously set by ITERATE.

NEXT_NODE
    is a node handle to be opened to the next node on the ITERATOR.

INTENT is the intent of subsequent operations on the node handle NEXT_NODE.

TIME_LIMIT is a value of type DURATION, specifying a time limit for the delay on waiting for the unlocking of the node in accordance with the desired INTENT.

Exceptions:

NAME_ERROR
is raised if the node whose node handle is to be returned in by NEXT_NODE is unobtainable and if the INTENT includes any intent other than EXISTENCE.

USE_ERROR is raised if the ITERATOR has not been previously set by ITERATE or if the iterator is exhausted (i.e., MORE (ITERATOR)=FALSE) or if INTENT is an empty array.

LOCK_ERROR
is raised if the opening of the node is delayed beyond the specified TIME_LIMIT due to the existence of locks in conflict with the specified INTENT.

ACCESS_VIOLATION
is raised if the current process' discretionary access control rights are insufficient to obtain access to the next node with the specified INTENT. Access Violation is raised only if the conditions for NAME_ERROR are not present.

SECURITY_VIOLATION
is raised if the current process' attempt to obtain access to the next node with the specified INTENT represents a violation of mandatory access controls for the CAIS. SECURITY_VIOLATION is raised only if the conditions for other exceptions are not present.

5.1.2.29. Setting the current node relationship

```
procedure SET_CURRENT_NODE(NODE: in NODE_TYPE);
```

Purpose:

This procedure specifies the node identified by NODE as the current node. The relationship of the predefined relation CURRENT_NODE of the current process is changed accordingly.

Parameters:

NODE is an open node handle to a node to be the new target of the CURRENT_NODE relationship emanating from the current process node.

Exceptions:

STATUS_ERROR
is raised if the node handle NODE is not open.

LOCK_ERROR
is raised if access, with intent WRITE_RELATIONSHIPS, to the current process node cannot be obtained due to an existing lock on the node.

SECURITY_VIOLATION
is raised if the operation represents a violation of mandatory access controls. SECURITY_VIOLATION is raised only if the conditions for other exceptions are not present.

Additional Interface:

```
procedure SET_CURRENT_NODE(NAME: in  NAME_STRING)
is
    NODE: NODE_TYPE;
begin
    OPEN(NODE, NAME, (1=>EXISTENCE));
    SET_CURRENT_NODE(NODE);
exception
    when others =>
        CLOSE(NODE);
        raise;
end SET_CURRENT_NODE;
```

5.1.2.30. Opening a node handle to the current node.

```
procedure GET_CURRENT_NODE(NODE:       in out NODE_TYPE;
                           INTENT:     in     INTENTION:=
                                                 (1=>EXISTENCE);
                           TIME_LIMIT: in DURATION:=NO_DELAY);
```

Purpose:

This procedure returns in NODE an open node handle to the current node of the current process; the intent with which the node handle is opened as specified by the INTENT parameter.

Parameter:

NODE — is a node handle, initially closed, to be opened to the current node.

INTENT — is the intent of subsequent operations on the node handle NODE.

TIME_LIMIT — is a value of type DURATION specifying a time limit for the delay on waiting for the unlocking of the node in accordance with the desired INTENT.

Exceptions:

NAME_ERROR
is raised if the current node is inaccessible or if it is unobtainable and the INTENT is anything other than EXISTENCE.

USE_ERROR is raised if INTENT is an empty array.

STATUS_ERROR
is raised if NODE is an open node handle prior to the call.

LOCK_ERROR
is raised if access, with intent READ_RELATIONSHIPS, to the current process node cannot be obtained due to an existing lock on the node.

ACCESS_VIOLATION
: is raised if the current process' discretionary access control rights are insufficient to obtain access to the current node with the specified INTENT. ACCESS_VIOLATION is raised only if the conditions for NAME_ERROR are not present.

SECURITY_VIOLATION
: is raised if the operation represents a violation of mandatory access controls. SECURITY_VIOLATION is raised only if the conditions other exceptions are not present.

Notes:

The call on GET_CURRENT_NODE is equivalent to OPEN(NODE, "'CURRENT_NODE", (INTENT,TIME_LIMIT)).

5.1.3. Package ATTRIBUTES

This package supports the definition and manipulation of attributes for nodes and relationships. The name of an attribute follows the syntax of an Ada identifier. The value of each attribute is a list; the format of the list is defined by the package LIST_UTILITIES (see Section 5.4). Upper and lower case distinctions are not significant within the attribute names.

Unless stated otherwise, the attributes predefined by the CAIS cannot be created, deleted or modified by the user.

The operations defined for the manipulation of attributes identify the node to which an attribute belongs either by pathname or open node handle. They implicitly identify a relationship to which an attribute belongs by the last path element of a pathname or explicitly identify the relationship by base node, key and relation name identification.

5.1.3.1. Creating node attributes

```
procedure CREATE_NODE_ATTRIBUTE(NODE:      in NODE_TYPE;
                                ATTRIBUTE: in ATTRIBUTE_NAME;
                                VALUE:     in LIST_TYPE);
```

Purpose:

This procedure creates an attribute named by ATTRIBUTE of the node identified by the open node handle NODE and sets its initial value to VALUE.

Parameters:

NODE	is an open node handle to a node to receive the new attribute.
ATTRIBUTE	is the name of the attribute.
VALUE	is the initial value of the attribute.

Exceptions:

USE_ERROR is raised if the node already has an attribute of the given name or if the attribute

name given is syntactically illegal. USE_ERROR is also raised if ATTRIBUTE is the name of a predefined node attribute which cannot be created by the user.

STATUS_ERROR
is raised if the node handle NODE is not open.

INTENT_VIOLATION
is raised if NODE was not opened with an intent establishing the right to append attributes.

SECURITY_VIOLATION
is raised if the operation represents a violation of mandatory access controls. SECURITY_VIOLATION is raised only if the conditions for other exceptions are not present.

Additional Interface:

```
procedure CREATE_NODE_ATTRIBUTE(NAME:      in NAME_STRING;
                                ATTRIBUTE: in ATTRIBUTE_NAME;
                                VALUE:     in LIST_TYPE)
is
    NODE: NODE_TYPE;
begin
    OPEN(NODE, NAME, (1=>APPEND_ATTRIBUTES));
    CREATE_NODE_ATTRIBUTE(NODE, ATTRIBUTE, VALUE);
    CLOSE(NODE);
exception
    when others =>
        CLOSE(NODE);
        raise;
end CREATE_NODE_ATTRIBUTE;
```

5.1.3.2. Creating path attributes

```
procedure CREATE_PATH_ATTRIBUTE(BASE:      in NODE_TYPE;
                                KEY:       in RELATIONSHIP_KEY;
                                RELATION:  in RELATION_NAME
                                              :=DEFAULT_RELATION;
                                ATTRIBUTE: in ATTRIBUTE_NAME;
                                VALUE:     in LIST_TYPE);
```

Purpose:

This procedure creates an attribute, named by ATTRIBUTE, of a relationship and sets its initial value to VALUE. The relationship is identified by the base node identified by the open node handle BASE, the relation name RELATION and the relationship key KEY.

Parameters:

BASE is an open node handle to the node from which the relationship emanates.

KEY is the relationship key of the affected relationship.

RELATION is the relation name of the affected relationship.

ATTRIBUTE is the attribute name.

VALUE is the initial value of the attribute.

Exceptions:

NAME_ERROR
is raised if the relationship identified by the BASE, KEY and RELATION parameters does not exist.

USE_ERROR is raised if the relationship already has an attribute of the given name or if the attribute name given is syntactically illegal. USE_ERROR is also raised if RELATION is the name of a predefined relation that cannot be modified by the user. USE_ERROR is also raised if ATTRIBUTE is the name of a predefined relationship attribute which cannot be created by the user.

STATUS_ERROR
is raised if the node handle BASE is not open.

INTENT_VIOLATION
is raised if BASE was not opened with an intent establishing the right to write relationships.

SECURITY_VIOLATION
is raised if the operation represents a violation of mandatory access controls. SECURITY_VIOLATION is raised only if the conditions for other exceptions are not present.

Additional Interface:

```
procedure CREATE_PATH_ATTRIBUTE(NAME:      in NAME_STRING;
                                ATTRIBUTE: in ATTRIBUTE_NAME;
                                VALUE:     in LIST_TYPE)
is
    BASE: NODE_TYPE;
begin
    OPEN(BASE, BASE_PATH(NAME), (1=>WRITE_RELATIONSHIPS));
    CREATE_PATH_ATTRIBUTE(BASE, LAST_KEY(NAME), LAST_RELATION(NAME),
                          ATTRIBUTE, VALUE);
    CLOSE(BASE);
exception
    when others =>
        CLOSE(BASE);
        raise;
end CREATE_PATH_ATTRIBUTE;
```

5.1.3.3. Deleting node attributes

```
procedure DELETE_NODE_ATTRIBUTE(NODE:      in NODE_TYPE;
                                ATTRIBUTE: in ATTRIBUTE_NAME);
```

Purpose:

This procedure deletes an attribute, named by ATTRIBUTE, of the node identified by the open node handle NODE.

Parameters:

NODE is an open node handle to a node whose attribute is to be deleted.

ATTRIBUTE is the name of the attribute to be deleted.

Exceptions:

USE_ERROR is raised if the node does not have an attribute of the given name. USE_ERROR is also raised if ATTRIBUTE is the name of a predefined node attribute which cannot be modified or created by the user.

STATUS_ERROR
is raised if the node handle NODE is not open.

INTENT_VIOLATION
is raised if NODE was not opened with an intent establishing the right to write attributes.

SECURITY_VIOLATION
is raised if the operation represents a violation of mandatory access controls. SECURITY_VIOLATION is raised only if the conditions for other exceptions are not present.

Additional Interface:

```
procedure DELETE_NODE_ATTRIBUTE(NAME      : in NAME_STRING;
                                ATTRIBUTE: in ATTRIBUTE_NAME)
is
    NODE: NODE_TYPE;
begin
    OPEN(NODE, NAME, (1=>WRITE_ATTRIBUTES));
    DELETE_NODE_ATTRIBUTE(NODE, ATTRIBUTE);
    CLOSE(NODE);
exception
    when others =>
        CLOSE(NODE);
        raise;
end DELETE_NODE_ATTRIBUTE;
```

5.1.3.4. Deleting path attributes

```
procedure DELETE_PATH_ATTRIBUTE(BASE:      in NODE_TYPE;
                                KEY:       in RELATIONSHIP_KEY;
                                RELATION:  in RELATION_NAME
                                             :=DEFAULT_RELATION;
                                ATTRIBUTE: in ATTRIBUTE_NAME);
```

Purpose:

This procedure deletes an attribute, named by ATTRIBUTE, of a relationship identified by the base node BASE, the relation name RELATION and the relationship key KEY.

Parameters:

BASE is an open node handle to the node from which the relationship emanates.

KEY is the relationship key of the affected relationship.

RELATION is the relation name of the affected relationship.

ATTRIBUTE is the attribute name of the attribute to be deleted.

Exceptions:

NAME_ERROR
is raised if the relationship identified by the BASE, KEY and RELATION parameters does not exist.

USE_ERROR is raised if the relationship does not have an attribute of the given name. USE_ERROR is also raised if RELATION is the name of a predefined relation that cannot be modified by the user. USE_ERROR is also raised if ATTRIBUTE is the name of a predefined relationship attribute which cannot be modified by the user.

STATUS_ERROR
is raised if the node handle BASE is not open.

INTENT_VIOLATION
is raised if BASE was not opened with an intent establishing the right to write relationships.

SECURITY_VIOLATION
is raised if the operation represents a violation of mandatory access controls. SECURITY_VIOLATION is raised only if the conditions for other exceptions are not present.

Additional Interface:

```
procedure DELETE_PATH_ATTRIBUTE(NAME:      in NAME_STRING;
                                ATTRIBUTE: in ATTRIBUTE_NAME)
is
    BASE: NODE_TYPE;
begin
    OPEN(BASE, BASE_PATH(NAME), (1=>WRITE_RELATIONSHIPS));
    DELETE_PATH_ATTRIBUTE(BASE, LAST_KEY(NAME), LAST_RELATION(NAME),
                          ATTRIBUTE);
    CLOSE(BASE);
exception
    when others =>
        CLOSE(BASE);
        raise;
end DELETE_PATH_ATTRIBUTE;
```

5.1.3.5. Setting node attributes

```
procedure SET_NODE_ATTRIBUTE(NODE:      in NODE_TYPE;
                             ATTRIBUTE: in ATTRIBUTE_NAME;
                             VALUE:     in LIST_TYPE);
```

Purpose:

This procedure sets the value of the node attribute named by ATTRIBUTE to the value given by VALUE. The node is identified by an open node handle NODE.

Parameters:

NODE — is an open node handle to a node the value of whose attribute named by ATTRIBUTE is to be set.

ATTRIBUTE — is the name of the attribute.

VALUE — is the new value of the attribute.

Exceptions:

USE_ERROR is raised if the node has no attribute of the given name. USE_ERROR is also raised if ATTRIBUTE is the name of a predefined node attribute which cannot be modified by the user.

STATUS_ERROR
is raised if NODE is not an open node handle.

INTENT_VIOLATION
is raised if NODE was not opened with an intent establishing the right to write attributes.

SECURITY_VIOLATION
is raised if the operation represents a violation of mandatory access controls. SECURITY_VIOLATION is raised only if the conditions for other exceptions are not present.

Additional Interface:

```
procedure SET_NODE_ATTRIBUTE(NAME:      in NAME_STRING;
                             ATTRIBUTE: in ATTRIBUTE_NAME;
                             VALUE:     in LIST_TYPE)
is
    NODE: NODE_TYPE;
begin
    OPEN(NODE, NAME, (1=>WRITE_ATTRIBUTES));
    SET_NODE_ATTRIBUTE(NODE, ATTRIBUTE, VALUE);
    CLOSE(NODE);
exception
    when others =>
        CLOSE(NODE);
        raise;
end SET_NODE_ATTRIBUTE;
```

5.1.3.6. Setting path attributes

```
procedure SET_PATH_ATTRIBUTE(BASE      : in NODE_TYPE;
                             KEY       : in RELATIONSHIP_KEY;
                             RELATION  : in RELATION_NAME
                                              :=DEFAULT_RELATION;
                             ATTRIBUTE : in ATTRIBUTE_NAME;
                             VALUE     : in LIST_TYPE);
```

Purpose:

This procedure sets the value of the relationship attribute named by ATTRIBUTE to the value

specified by VALUE. The relationship is identified explicitly by the base node BASE, the relation name RELATION and the relationship key KEY.

Parameters:

BASE	is an open node handle to the node from which the relationship emanates.
KEY	is the relationship key of the affected relationship.
RELATION	is the relation name of the affected relationship.
ATTRIBUTE	is the name of the attribute.
VALUE	is the new value of the attribute.

Exceptions:

NAME_ERROR
: is raised if the relationship identified by the BASE, KEY and RELATION parameters does not exist.

USE_ERROR
: is raised if the node does not have an attribute of the given name. USE_ERROR is also raised if RELATION is the name of a predefined relation that cannot be modified by the user. USE_ERROR is also raised if ATTRIBUTE is the name of a predefined relationship attribute which cannot be modified by the user.

STATUS_ERROR
: is raised if the node handle BASE is not open.

INTENT_VIOLATION
: is raised if BASE was not opened with an intent establishing the right to write relationships.

SECURITY_VIOLATION
: is raised if the operation represents a violation of mandatory access controls. SECURITY_VIOLATION is raised only if the conditions for other exceptions are not present.

Additional Interface:

```
procedure SET_PATH_ATTRIBUTE(NAME:      in NAME_STRING;
                             ATTRIBUTE: in ATTRIBUTE_NAME;
                             VALUE:     in LIST_TYPE)
is
    BASE: NODE_TYPE;
begin
    OPEN(BASE, BASE_PATH(NAME), (1=>WRITE_RELATIONSHIPS));
    SET_PATH_ATTRIBUTE(BASE, LAST_KEY(NAME), LAST_RELATION(NAME),
                       ATTRIBUTE, VALUE);
    CLOSE(BASE);
exception
    when others =>
        CLOSE(BASE);
        raise;
end SET_PATH_ATTRIBUTE;
```

5.1.3.7. Getting node attributes

```
procedure GET_NODE_ATTRIBUTE(NODE:      in     NODE_TYPE;
                             ATTRIBUTE: in     ATTRIBUTE_NAME;
                             VALUE:     in out LIST_TYPE);
```

Purpose:

This procedure returns the value of the node attribute named by ATTRIBUTE in the parameter VALUE. The node is identified by open node handle NODE.

Parameters:

NODE — is an open node handle to a node the value of whose attribute ATTRIBUTE is to be retrieved.

ATTRIBUTE — is the name of the attribute.

VALUE — is the result parameter containing the value of the attribute.

Exceptions:

USE_ERROR is raised if the node has no attribute of name ATTRIBUTE.

STATUS_ERROR
is raised if NODE is not an open node handle.

INTENT_VIOLATION
is raised if NODE was not opened with an intent establishing the right to read attributes.

Additional Interface:

```
procedure GET_NODE_ATTRIBUTE(NAME:      in NAME_STRING;
                             ATTRIBUTE: in ATTRIBUTE_NAME;
                             VALUE:     in out LIST_TYPE)
is
    NODE: NODE_TYPE;
begin
    OPEN(NODE, NAME, (1=>READ_ATTRIBUTES));
    GET_NODE_ATTRIBUTE(NODE, ATTRIBUTE, VALUE);
    CLOSE(NODE);
exception
    when others =>
        CLOSE(NODE);
        raise;
end GET_NODE_ATTRIBUTE;
```

5.1.3.8. Getting path attributes

```
procedure GET_PATH_ATTRIBUTE(BASE:      in     NODE_TYPE;
                             KEY:       in     RELATIONSHIP_KEY;
                             RELATION:  in     RELATION_NAME
                                           :=DEFAULT_RELATION;
                             ATTRIBUTE: in     ATTRIBUTE_NAME;
                             VALUE:     in out LIST_TYPE);
```

Purpose:

This procedure assigns the value of the relationship attribute named by ATTRIBUTE to the parameter VALUE. The relationship is identified explicitly by the base node BASE, the relation name RELATION and the relationship key KEY.

Parameters:

BASE is an open node handle to the node from which the relationship emanates.

KEY is the relationship key of the accessed relationship.

RELATION is the relation name of the accessed relationship.

ATTRIBUTE is the name of the attribute.

VALUE is the result parameter containing the value of the attribute.

Exceptions:

NAME_ERROR
is raised if the relationship identified by the BASE, KEY and RELATION parameters does not exist.

USE_ERROR is raised if the relationship does not have an attribute of the given name.

STATUS_ERROR
is raised if the node handle BASE is not open.

INTENT_VIOLATION
is raised if BASE was not opened with an intent establishing the right to read relationships.

Additional Interface:

```
procedure GET_PATH_ATTRIBUTE(NAME:      in     NAME_STRING;
                             ATTRIBUTE: in     ATTRIBUTE_NAME;
                             VALUE:     in out LIST_TYPE)
is
    BASE: NODE_TYPE;
begin
    OPEN(BASE, BASE_PATH(NAME), (1=>READ_RELATIONSHIPS));
    GET_PATH_ATTRIBUTE(BASE, LAST_KEY(NAME), LAST_RELATION(NAME),
                       ATTRIBUTE, VALUE);
    CLOSE(BASE);
exception
    when others =>
        CLOSE(BASE);
        raise;
end GET_PATH_ATTRIBUTE;
```

5.1.3.9. Attribute iteration types and subtypes

```
subtype ATTRIBUTE_NAME is STRING;
type    ATTRIBUTE_ITERATOR is limited private;
subtype ATTRIBUTE_PATTERN is STRING;
```

These types are used in the following interfaces for iteration over a set of attributes of nodes or relationships. ATTRIBUTE_NAME is a subtype for the names of attributes. An ATTRIBUTE_PATTERN has the same syntax as an ATTRIBUTE_NAME, except that '?' will match any single character and '*' will match any string of characters. ATTRIBUTE_ITERATOR is a private type assumed to contain the bookkeeping information necessary for the implementation of the MORE and GET_NEXT functions. The attributes are returned by GET_NEXT in ASCII lexicographical order by attribute name. The effect on existing iterators of creation or deletion of attributes or relationships is implementation-defined.

5.1.3.10. Creating an iterator over node attributes

```
procedure NODE_ATTRIBUTE_ITERATE(ITERATOR:  out ATTRIBUTE_ITERATOR;
                                 NODE:      in  NODE_TYPE;
                                 PATTERN:   in  ATTRIBUTE_PATTERN
                                                :="*");
```

Purpose:

The procedure NODE_ATTRIBUTE_ITERATE returns in the parameter ITERATOR an attribute iterator according to the semantic rules for attribute selection given in Section 5.1.3.9.

Parameters:

ITERATOR is the attribute iterator returned.

NODE is an open node handle to a node over whose attributes the iterator is to be constructed.

PATTERN is a pattern for attribute names as described in Section 5.1.3.9.

Exceptions:

USE_ERROR is raised if the PATTERN is syntactically illegal.

STATUS_ERROR
is raised if NODE is not an open node handle.

INTENT_VIOLATION
is raised if NODE is not open with an intent establishing the right to read attributes.

Additional Interface:

```
procedure NODE_ATTRIBUTE_ITERATE(ITERATOR:  out ATTRIBUTE_ITERATOR;
                                 NAME:      in  NAME_STRING;
                                 PATTERN:   in  ATTRIBUTE_PATTERN
                                                :="*")
  is
     NODE: NODE_TYPE;
  begin
```

```
        OPEN(NODE, NAME, (1=>READ_ATTRIBUTES));
        NODE_ATTRIBUTE_ITERATE(ITERATOR, NODE, PATTERN);
        CLOSE(NODE);
    exception
        when others =>
            CLOSE(NODE);
            raise;
    end NODE_ATTRIBUTE_ITERATE;
```

Notes:

By using the pattern '*', it is possible to iterate over all attributes of a node.

5.1.3.11. Creating an iterator over relationship attributes

```
procedure PATH_ATTRIBUTE_ITERATE(ITERATOR:   out ATTRIBUTE_ITERATOR;
                                 BASE:       in  NODE_TYPE;
                                 KEY:        in  RELATIONSHIP_KEY;
                                 RELATION:   in  RELATION_NAME
                                                 :=DEFAULT_RELATION;
                                 PATTERN:    in  ATTRIBUTE_PATTERN
                                                 :="*");
```

Purpose:

This procedure is provided to obtain an attribute iterator for relationship attributes. The relationship is identified explicitly by the base node BASE, the relation name RELATION and the relationship key KEY. The procedure returns an attribute iterator in ITERATOR according to the semantic rules for attribute selection applied to the attributes of the identified relationship. This iterator can then be processed by means of the MORE and GET_NEXT interfaces.

Parameters:

ITERATOR	is the attribute iterator returned.
BASE	is an open node handle to the node from which the relationship emanates.
KEY	is the relationship key of the affected relationship.
RELATION	is the relation name of the affected relationship.
PATTERN	is a pattern for attribute names (see Section 5.1.3.9).

Exceptions:

NAME_ERROR
: is raised if the relationship identified by the BASE, KEY and RELATION parameters does not exist.

USE_ERROR is raised if the PATTERN is syntactically illegal.

STATUS_ERROR
: is raised if BASE is not an open node handle.

INTENT_VIOLATION
: is raised if BASE was not opened with an intent establishing the right to read relationships.

Additional Interface:

```
procedure PATH_ATTRIBUTE_ITERATE(ITERATOR:    out ATTRIBUTE_ITERATOR;
                                 NAME:        in   NAME_STRING;
                                 PATTERN:     in   ATTRIBUTE_PATTERN
                                                   :="*")
  is
     BASE: NODE_TYPE;
  begin
     OPEN(BASE, BASE_PATH(NAME), (1=>READ_RELATIONSHIPS));
     PATH_ATTRIBUTE_ITERATE(ITERATOR, BASE, LAST_KEY(NAME),
                            LAST_RELATION(NAME), PATTERN);
     CLOSE(BASE);
  exception
     when others =>
        CLOSE(BASE);
        raise;
  end PATH_ATTRIBUTE_ITERATE;
```

5.1.3.12. Determining iteration status

```
function MORE(ITERATOR: in ATTRIBUTE_ITERATOR)
     return BOOLEAN;
```

Purpose:

The function MORE returns FALSE if all attributes contained in the attribute iterator have been retrieved with the procedure GET_NEXT; otherwise, it returns TRUE.

Parameters:

ITERATOR is an attribute iterator previously constructed.

Exceptions:

USE_ERROR is raised if the ITERATOR has not been previously set by the procedures NODE_ATTRIBUTE_ITERATE or PATH_ATTRIBUTE_ITERATE.

5.1.3.13. Getting the next attribute

```
procedure GET_NEXT(ITERATOR:  in out ATTRIBUTE_ITERATOR;
                   ATTRIBUTE:    out ATTRIBUTE_NAME;
                   VALUE:     in out LIST_TYPE);
```

Purpose:

The procedure GET_NEXT returns, in its parameters ATTRIBUTE and VALUE, both the name and the value of the next attribute in the iterator.

Parameters:

ITERATOR is an attribute iterator previously constructed.

ATTRIBUTE is a result parameter containing the name of an attribute.

VALUE is a result parameter containing the value of the attribute named by ATTRIBUTE.

Exceptions:

USE_ERROR is raised if the ITERATOR has not been previously set by the procedures

NODE_ATTRIBUTE_ITERATE or PATH_ATTRIBUTE_ITERATE or if the iterator is exhausted, i.e., MORE(ITERATOR)= FALSE.

5.1.4. Package ACCESS_CONTROL

This package provides primitives for manipulating discretionary access control information for CAIS nodes. In addition, certain CAIS subprograms declared elsewhere allow the specification of initial access control information. The CAIS specifies mechanisms for discretionary and mandatory access control (see [TCSEC]). These mechanisms are only recommendations. Alternate discretionary or mandatory access control mechanisms can be substituted by an implementation provided that the semantics of all interfaces in Section 5 (with the exception of Section 5.1.4) are implemented as specified.

5.1.4.1. Subtypes

```
subtype GRANT_VALUE is CAIS.LIST_UTILITIES.LIST_TYPE;
```

GRANT_VALUE is a subtype for values of GRANT attributes; it is a list in the syntax described in Table II.

5.1.4.2. Setting access control

```
procedure SET_ACCESS_CONTROL(NODE:      in NODE_TYPE;
                             ROLE_NODE: in NODE_TYPE;
                             GRANT:     in GRANT_VALUE);
```

Purpose:

This procedure sets access control information for a given node. If a relationship of the predefined relation ACCESS does not exist from the node identified by NODE to the node identified by ROLE_NODE, such a relationship with an implementation-defined relationship key is created from the node specified by NODE to the node specified by ROLE_NODE. If necessary, the predefined attribute GRANT is created on this relationship. The value of the GRANT attribute is set to the value of the GRANT parameter (see Table II for the syntax). The effect is to grant the access specified by GRANT to processes that have adopted the role ROLE_NODE.

Parameters:

NODE — is an open node handle to the node whose access control information is to be set.

ROLE_NODE — is an open node handle to the node representing the role.

GRANT — is a list describing what access rights can be granted.

Exceptions:

USE_ERROR is raised if GRANT is not in valid syntax.

STATUS_ERROR — is raised if NODE and ROLE_NODE are not both open node handles.

INTENT_VIOLATION — is raised if NODE was not opened with intent CONTROL.

SECURITY_VIOLATION
is raised if the operation represents a violation of mandatory access controls. SECURITY_VIOLATION is raised only if the conditions for other exceptions are not present.

Additional Interface:

```
procedure SET_ACCESS_CONTROL(NAME:      in NAME_STRING;
                             ROLE_NAME: in NAME_STRING;
                             GRANT:     in GRANT_VALUE)
is
    NODE, ROLE_NODE: NODE_TYPE;
begin
    OPEN(NODE, NAME, (1=>CONTROL));
    OPEN(ROLE_NODE, ROLE_NAME, (1=>EXISTENCE));
    SET_ACCESS_CONTROL(NODE, ROLE_NODE, GRANT);
    CLOSE(NODE);
    CLOSE(ROLE_NODE);
exception
    when others =>
        CLOSE(NODE);
        CLOSE(ROLE_NODE);
        raise;
end SET_ACCESS_CONTROL;
```

5.1.4.3. Examining access rights

```
function IS_GRANTED(OBJECT_NODE : in NODE_TYPE;
                    ACCESS_RIGHT: in NAME_STRING)
    return BOOLEAN;
```

Purpose:

This function returns TRUE if the current process as a subject has an approved access right ACCESS_RIGHT to the OBJECT_NODE as an object. Otherwise it returns FALSE.

Parameters:

OBJECT_NODE
is an open node handle to the object node.

ACCESS_RIGHT
is the name of a predefined or user-defined access right.

Exceptions:

USE_ERROR is raised if ACCESS_RIGHT is not a valid Ada identifier.

STATUS_ERROR
is raised if OBJECT_NODE is not an open node handle.

INTENT_VIOLATION
is raised if OBJECT_NODE was not opened with an intent establishing the right to read relationships or to read access control information.

Additional Interface:

```
function IS_GRANTED(OBJECT_NAME:  in NAME_STRING;
                    ACCESS_RIGHT: in NAME_STRING)
        return BOOLEAN
is
    OBJECT_NODE: NODE_TYPE;
    RESULT:      BOOLEAN;
begin
    OPEN(OBJECT_NODE, OBJECT_NAME, (1=>READ_RELATIONSHIPS));
    RESULT := IS_GRANTED(OBJECT_NODE, ACCESS_RIGHT);
    CLOSE(OBJECT_NODE);
        return RESULT;
exception
    when others =>
        CLOSE(OBJECT_NODE);
        raise;
end IS_GRANTED;
```

5.1.4.4. Adopting a role

```
procedure ADOPT(ROLE_NODE: in NODE_TYPE;
                ROLE_KEY:  in RELATIONSHIP_KEY:=LATEST_KEY);
```

Purpose:

This procedure causes the current process to adopt the group specified by the ROLE_NODE. A relationship of the predefined relation ADOPTED_ROLE with relationship key ROLE_KEY is created from the calling process node to the node identified by ROLE_NODE. In order for the current process to adopt the group, a node representing some other adopted role of the current process must be a potential member of the group to be adopted.

Parameters:

ROLE_NODE
: is an open node handle to a node representing the group.

ROLE_KEY
: is a relationship key to be used in creating the relationship.

Exceptions:

USE_ERROR
: is raised if there is no adopted role of the current process that is a potential member of the group represented by ROLE_NODE or if there already exists a relationship of the predefined relation ADOPTED_ROLE with relationship key ROLE_KEY emanating from the current process node. USE_ERROR is also raised if the node identified by ROLE_NODE is inaccessible or unobtainable.

STATUS_ERROR
: is raised if ROLE_NODE is not an open node handle.

LOCK_ERROR
: is raised if access with intent APPEND_RELATIONSHIPS to the current process node cannot be obtained due to an existing lock on the node.

SECURITY_VIOLATION
: is raised if the operation represents a violation of mandatory access controls. SECURITY_VIOLATION is raised only if the conditions for other exceptions are not present.

5.1.4.5. Unlinking an adopted role

```
procedure UNADOPT(ROLE_KEY: in RELATIONSHIP_KEY);
```

Purpose:

This procedure deletes the relationship of the predefined relation ADOPTED_ROLE with relationship key ROLE_KEY emanating from the current process node. If there is no such relationship, the procedure has no effect.

Parameters:

ROLE_KEY is the relationship key of the relation ADOPTED_ROLE

Exception:

USE_ERROR is raised if the target node of the relationship to be deleted is the top-level node identified by "'CURRENT_USER". In this case the relationship is not deleted.

LOCK_ERROR
is raised if access, with intent WRITE_RELATIONSHIPS, to the current process node cannot be obtained due to an existing lock on the node.

5.1.5. Package STRUCTURAL_NODES

Structural nodes are special nodes in the sense that they do not have contents as the other nodes of the CAIS model do. *Their purpose is solely to be carriers of common information* about other nodes related to the structural node. Structural nodes are typically used to create conventional directories, configuration objects, etc..

The package STRUCTURAL_NODES defines the primitive operations for creating structural nodes.

5.1.5.1. Creating structural nodes

```
procedure CREATE_NODE(NODE:           in out NODE_TYPE;
                      BASE:           in     NODE_TYPE;
                      KEY:            in     RELATIONSHIP_KEY
                                           :=LATEST_KEY;
                      RELATION:       in     RELATION_NAME
                                           :=DEFAULT_RELATION;
                      ATTRIBUTES:     in LIST_TYPE := EMPTY_LIST;
                      ACCESS_CONTROL: in LIST_TYPE := EMPTY_LIST;
                      LEVEL:          in LIST_TYPE := EMPTY_LIST);
```

Purpose:

This procedure creates a structural node and installs the primary relationship to it. The relation name and relationship key of the primary relationship to the node and the base node from which it emanates are given by the parameters RELATION, KEY, and BASE. An open node handle to the newly created node with WRITE intent is returned in NODE.

The ATTRIBUTES parameter defines and provides initial values for attributes of the node. The ACCESS_CONTROL parameter specifies initial access control information to be established for the created node (see Section 4.4).

The LEVEL parameter specifies the security level at which the node is to be created.

Parameters:

NODE is a node handle, initially closed, to be opened to the newly created node.

BASE is an open node handle to the node from which the primary relationship to the new node is to emanate.

KEY is the relationship key of the primary relationship to be created.

RELATION is the relation name of the primary relationship to be created.

ATTRIBUTES is a named list (see Section 5.4) whose elements are used to establish initial values for attributes of the newly created node; each named item specifies an attribute name and the value to be given to that attribute.

ACCESS_CONTROL
is the initial access control information associated with the created node; it is a named list (see Section 5.4) each of whose named items specifies a relationship key followed by a list of access rights.

LEVEL is the classification label for the created node (see TABLE IV).

Exceptions:

NAME_ERROR
is raised if a node already exists for the node identification given, if the node identification is illegal, or if any node identifying a group specified in the given ACCESS_CONTROL parameter is unobtainable or inaccessible.

USE_ERROR is raised if the ACCESS_CONTROL or LEVEL parameters do not adhere to the required syntax or if the ATTRIBUTES parameter contains references to predefined attributes which cannot be modified or created by the user. USE_ERROR is also raised if RELATION is the name of a predefined relation that cannot be modified or created by the user.

STATUS_ERROR
is raised if BASE is not an open node handle or if NODE is an open node handle prior to the call.

INTENT_VIOLATION
is raised if BASE was not opened with an intent establishing the right to append relationships.

SECURITY_VIOLATION
is raised if the operation represents a violation of mandatory access controls. SECURITY_VIOLATION is raised only if the conditions for other exceptions are not present.

Additional Interfaces:

```
procedure CREATE_NODE(NODE:          in out NODE_TYPE;
                      NAME:          in     NAME_STRING;
```

```
                            ATTRIBUTES:     in LIST_TYPE := EMPTY_LIST;
                            ACCESS_CONTROL: in LIST_TYPE := EMPTY_LIST;
                            LEVEL:          in LIST_TYPE := EMPTY_LIST);
is
    BASE: NODE_TYPE;

begin
    OPEN(BASE, BASE_PATH(NAME), (1=>APPEND_RELATIONSHIPS));
    CREATE_NODE(NODE, BASE, LAST_KEY(NAME), LAST_RELATION(NAME),
            ATTRIBUTES, ACCESS_CONTROL, LEVEL);
    CLOSE(BASE);
exception
    when others =>
        CLOSE(NODE);
        CLOSE(BASE);
        raise;
end CREATE_NODE;

procedure CREATE_NODE(BASE:           in NODE_TYPE;
                      KEY:            in RELATIONSHIP_KEY
                                       :=LATEST_KEY;
                      RELATION:       in RELATION_NAME
                                       :=DEFAULT_RELATION;
                      ATTRIBUTES:     in LIST_TYPE := EMPTY_LIST;
                      ACCESS_CONTROL: in LIST_TYPE := EMPTY_LIST;
                      LEVEL:          in LIST_TYPE := EMPTY_LIST;
is
    NODE: NODE_TYPE;
begin
    CREATE_NODE(NODE,KEY,RELATION,ATTRIBUTES,ACCESS_CONTROL,LEVEL);
    CLOSE(NODE);
end CREATE_NODE;

procedure CREATE_NODE (NAME:           in NAME_STRING;
                       ATTRIBUTES:     in LIST_TYPE := EMPTY_LIST;
                       ACCESS_CONTROL: in LIST_TYPE := EMPTY_LIST;
                       LEVEL:          in LIST_TYPE := EMPTY_LIST);
is
    NODE: NODE_TYPE;
begin
    CREATE_NODE(NODE, NAME, ATTRIBUTES, ACCESS_CONTROL, LEVEL);
    CLOSE(NODE);
end CREATE_NODE;
```

Notes:

Use of the sequence of a CREATE_NODE call that does not return an open node handle followed by a call on OPEN for the created node, using the node identification of the created node, cannot guarantee that a handle to the node just created is opened; this is because relationships, and therefore the node identification, may have changed since the CREATE_NODE call.

5.2. CAIS process nodes

This section describes the semantics of the execution of Ada programs as represented by CAIS processes and the facilities provided by the CAIS for initiating and controlling processes. The major stages in a process' life are initiation, running (which may include suspension or resumption), and termination or abortion. The CAIS defines facilities to control and coordinate the initiation, suspension, resumption, and termination or abortion of processes (see Section 4.3.2). Each CAIS process has a current status associated with it which changes with certain events as specified in TABLE VI.

A process is said to be *terminated* when its main program (in the sense of [LRM] 10.1) has terminated (in the sense of [LRM] 9.4). See also the notes in [LRM] 9.4. Thus, termination of a process takes place when the main program has been completed and all tasks dependent on the main program have terminated. A process may be *aborted* either by itself or by another process. When a process has terminated or has been aborted, all of its dependent processes which have not already terminated or been aborted will be aborted but its process node remains until explicitly deleted. Any open node handles of a process are closed when the process terminates or is aborted.

Two mechanisms for a process to initiate another process are provided:

a. Spawn - the procedure SPAWN_PROCESS returns after initiating the specified program. The initiating process and the initiated process run in parallel, and, within each of them, their tasks may execute in parallel.

b. Invoke - the procedure INVOKE_PROCESS returns control to the calling task after the initiated process has terminated or aborted. Execution of the calling task is blocked until termination or abortion of the initiated process, but other tasks in the initiating process may execute in parallel with the initiated process and its tasks.

Every process node has several predefined attributes. Three of these are: RESULTS, which can be used to store user-defined strings giving intermediate results of the process; PARAMETERS, which contains the parameters with which the process was initiated; and CURRENT_STATUS, which gives the current status of the process (see TABLE VI). In addition, every process node has several predefined attributes which provide information for standardized debugging and performance measurement of processes within the CAIS implementation. One of these predefined attributes, HANDLES_OPEN, has an implementation-independent value which gives the number of node handles the process currently has open. The remaining predefined attributes have implementation-dependent values and should not be used for comparison with values from other CAIS implementations. START_TIME and FINISH_TIME give the time of activation and the time of termination or abortion of the process. MACHINE_TIME gives the length of time the process was active on the logical processor, if the process has terminated or aborted, or zero, if the process has not terminated or aborted. IO_UNITS gives the number of GET and PUT operations that have been performed by the process. The CURRENT_STATUS, HANDLES_OPEN, START_TIME, FINISH_TIME, MACHINE_TIME, and IO_UNITS predefined attributes are maintained by the implementation and cannot be set using CAIS interfaces.

When a process has terminated or aborted, the final status, recorded in the predefined process node attribute CURRENT_STATUS, will persist as long as the process node exists. CURRENT_STATUS may also be examined by the CAIS procedures STATE_OF_PROCESS and GET_RESULTS. The process status of a process will be returned to any task awaiting the termination or abortion of the process whenever the process is terminated or aborted. If the process has already been terminated or aborted at the time a call to AWAIT_PROCESS_COMPLETION is made, then the final status is immediately available.

For purposes of input and output, every process node has one relationship of each of the following predefined relations: STANDARD_INPUT, STANDARD_OUTPUT, STANDARD_ERROR, CURRENT_INPUT, CURRENT_OUTPUT, and CURRENT_ERROR. STANDARD_INPUT, STANDARD_OUTPUT and STANDARD_ERROR are relation names of relationships established at job creation to the default input, output and error files, respectively. The STANDARD_INPUT and STANDARD_OUTPUT files conform to the semantics given for these in [LRM] 14.3.2. CURRENT_INPUT, CURRENT_OUTPUT and CURRENT_ERROR are relation names of relationships established by a process to alternative files to be used as the default input, output and error files, respectively. CURRENT_INPUT and CURRENT_OUTPUT also conform to the

semantics of [LRM] 14.3.2. Interfaces are provided in the CAIS input and output packages (see Section 5.3) to read relationships of these predefined relations and to change the relationships of the relations CURRENT_INPUT, CURRENT_OUTPUT, and CURRENT_ERROR.

Table VI. Process status transition table

status: event	non_existent	READY	SUSPENDED	ABORTED	TERMINATED
process creation	READY	N/A	N/A	N/A	N/A
termination of main program	N/A	TERM-INATED	N/A	N/A	N/A
ABORT_ PROCESS	N/A	ABOR-TED	ABORTED	---	---
SUSPEND_ PROCESS	N/A	SUS-PENDED	---	---	---
RESUME_ PROCESS	N/A	---	READY	---	---

N/A: marks events that are not applicable to the status specified.

---: marks events that have no effect on the status.

upper case: status which are values of the enumeration type PROCESS_STATUS (e.g., READY) and for events which are caused by calling CAIS interfaces (e.g., ABORT_PROCESS).

lower case: other status (i.e., non-existent) and other events (e.g., termination of the main program).

5.2.1. Package PROCESS_DEFINITIONS

This package defines the types and exceptions associated with process nodes.

```
type PROCESS_STATUS is
          (READY, SUSPENDED, ABORTED, TERMINATED);
```

An object of type PROCESS_STATUS is the status of a process.

```
subtype RESULTS_LIST      is CAIS.LIST_UTILITIES.LIST_TYPE;
subtype RESULTS_STRING    is STRING;
subtype PARAMETER_LIST    is CAIS.LIST_UTILITIES.LIST_TYPE;
```

An object of type RESULTS_LIST is a list of results from a process. The elements of this list are of type RESULTS_STRING. An object of type PARAMETER_LIST is a list containing process parameter information.

```
ROOT_PROCESS   : constant NAME_STRING := "'CURRENT_JOB";
CURRENT_INPUT  : constant NAME_STRING := "'CURRENT_INPUT";
CURRENT_OUTPUT : constant NAME_STRING := "'CURRENT_OUTPUT";
CURRENT_ERROR  : constant NAME_STRING := "'CURRENT_ERROR";
```

ROOT_PROCESS is a standard pathname for the root process node of the current job. CURRENT_INPUT, CURRENT_OUTPUT and CURRENT_ERROR are standard pathnames for the current process' input, output and error files, respectively.

5.2.2. Package PROCESS_CONTROL

This package specifies interfaces for the creation and termination of processes and examination and modification of process node attributes.

As part of the creation of process nodes, new secondary relationships are built as described in TABLE VII.

Table VII. Created and inherited relationships

A secondary relationship of the predefined relation:	is created to the node identified by:
CURRENT_INPUT	the interface parameter INPUT_FILE
CURRENT_OUTPUT	the interface parameter OUTPUT_FILE
CURRENT_ERROR	the interface parameter ERROR_FILE
ADOPTED_ROLE	the interface parameter FILE_NODE
CURRENT_NODE	the interface parameter ENVIRONMENT_NODE
PARENT	the predefined constant CURRENT_PROCESS (for dependent process nodes) the predefined constant CURRENT_USER (for root process nodes)

The created process node inherits all secondary relationships of the following predefined relations from the creating process node:

CURRENT_USER
USER
ALLOW_ACCESS
DEVICE
STANDARD_INPUT
STANDARD_OUTPUT
STANDARD_ERROR
ADOPTED_ROLE [1]
CURRENT_JOB [2]

1. For CREATE_JOB, only the relationship of the predefined relation ADOPTED_ROLE with the CURRENT_USER as target is inherited from the creating process node.

2. For CREATE_JOB, a relationship of the predefined relation CURRENT_JOB is created with the new node as both source and target instead of being inherited from the creating process node.

5.2.2.1. Spawning a process

```
procedure SPAWN_PROCESS
        (NODE:                in out NODE_TYPE;
         FILE_NODE:           in     NODE_TYPE;
         INPUT_PARAMETERS:    in     PARAMETER_LIST:=EMPTY_LIST;
         KEY:                 in     RELATIONSHIP_KEY := LATEST_KEY;
         RELATION:            in     RELATION_NAME := DEFAULT_RELATION;
         ACCESS_CONTROL:      in     LIST_TYPE := EMPTY_LIST;
         LEVEL:               in     LIST_TYPE := EMPTY_LIST;
         ATTRIBUTES:          in     LIST_TYPE := EMPTY_LIST;
         INPUT_FILE:          in     NAME_STRING := CURRENT_INPUT;
         OUTPUT_FILE:         in     NAME_STRING := CURRENT_OUTPUT;
         ERROR_FILE:          in     NAME_STRING := CURRENT_ERROR;
         ENVIRONMENT_NODE:    in     NAME_STRING := CURRENT_NODE);
```

Purpose:

This procedure creates a new process node whose contents represent the execution of the program contained in the specified file node. Control returns to the calling task after the new node is created. The process node containing the calling task must have execution rights for the file node. An open node handle NODE on the new node is returned, with an intent (I=> READ_ATTRIBUTES). The new process, as a subject, has all discretionary access rights to its own process node (the object). When the parent process terminates or aborts, the child process will be aborted.

Secondary relationships emanating from the new process node are created and inherited as described in TABLE VI.

The ACCESS_CONTROL parameter specifies the initial access control information to be established for the created node. If the CAIS models of discretionary and mandatory access control are used, then, in addition to the relationships established using the information in the ACCESS_CONTROL parameter, an access relationship is established from the created process node to the current user node, with a GRANT attribute value ((READ, WRITE, CONTROL)).

The LEVEL parameter specifies the security level at which the node is to be created.

Parameters:

NODE — is a node handle returned open on the newly created process node.

FILE_NODE — is an open node handle on the file node containing the executable image whose execution will be represented by the new process.

INPUT_PARAMETERS — is a list containing process parameter information. The list is constructed and parsed using the tools provided in CAIS.LIST_UTILITIES (see Section 5.4). The value of INPUT_PARAMETERS stored in a predefined attribute PARAMETERS of the new node.

KEY — is the relationship key of the primary relationship from the current process node to the new process node. The default is supplied by the mechanism of interpreting the LATEST_KEY constant.

RELATION — is the relation name of the primary relationship from the current process node to the new process node. The default is DEFAULT_RELATION.

ACCESS_CONTROL
is a string defining the initial access control information associated with the created node.

LEVEL is a string defining the classification label for the created node (see TABLE IV).

ATTRIBUTES is a list which can be used to set attributes of the new node. It could be used by an implementation to establish allocation of resources.

INPUT_FILE, OUTPUT_FILE, ERROR_FILE
are pathnames to file nodes.

ENVIRONMENT_NODE
is the node the new process will have as its initial current node. The default value is the CURRENT_NODE of the initiating process.

Exceptions:

NAME_ERROR
is raised if a node already exists for the relationship specified by KEY and RELATION. NAME_ERROR is also raised if any of the nodes identified by INPUT_FILE, OUTPUT_FILE, ERROR_FILE, or ENVIRONMENT_NODE do not exist. It is also raised if KEY or RELATION is syntactically illegal or if any node identifying a group specified in the given ACCESS_CONTROL parameter is unobtainable or inaccessible.

USE_ERROR is raised if it can be determined that the node indicated by FILE_NODE does not contain an executable image. USE_ERROR is also raised if any of the parameters INPUT_PARAMETERS, LEVEL, ACCESS_CONTROL, or ATTRIBUTES is syntactically or semantically illegal. USE_ERROR is also raised if RELATION is the name of a predefined relation or if the ATTRIBUTES parameter contains references to a predefined attribute which cannot be modified or created by the user.

STATUS_ERROR
is raised if NODE is an open node handle prior to the call or if FILE_NODE is not an open node handle.

LOCK_ERROR
is raised if access with intent APPEND_ RELATIONSHIPS to the current process node cannot be obtained due to an existing lock on the node.

INTENT_VIOLATION
is raised if the node designated by FILE_NODE was not opened with an intent establishing the right to execute its contents.

Notes:

SPAWN_PROCESS does not return results or process status. If coordination between any task and the new process is desired, AWAIT_PROCESS_COMPLETION or the techniques provided in CAIS input and output (see Section 5.3) must be used.

5.2.2.2. Awaiting termination or abortion of another process

```
procedure AWAIT_PROCESS_COMPLETION
        (NODE:              in NODE_TYPE;
         TIME_LIMIT:        in     DURATION := DURATION'LAST);
```

Purpose:

This procedure suspends the calling task and waits for the process identified by NODE to terminate or abort. The calling task is suspended until the identified process terminates or aborts or until the time limit is exceeded.

Parameters:

NODE is an open node handle for the process to be awaited.

TIME_LIMIT is the limit on the time that the calling task will be suspended awaiting the process. When the limit is exceeded the calling task resumes execution. The default is the implementation-dependent maximum value for DURATION.

Exceptions:

NAME_ERROR
is raised if the node identified by NODE is inaccessible or unobtainable.

STATUS_ERROR
is raised if NODE is not an open node handle.

INTENT_VIOLATION
is raised if NODE was not opened with an intent establishing the right to read attributes.

Additional interface:

```
procedure AWAIT_PROCESS_COMPLETION
        (NODE             : in     NODE_TYPE;
         RESULTS_RETURNED : in out RESULTS_LIST;
         STATUS           :    out PROCESS_STATUS;
         TIME_LIMIT       : in     DURATION := DURATION'LAST)
is
begin
     AWAIT_PROCESS_COMPLETION (NODE, TIME_LIMIT);
     GET_RESULTS (NODE, RESULTS_RETURNED);
     STATUS := STATUS_OF_PROCESS (NODE);
end AWAIT_PROCESS_COMPLETION;
```

5.2.2.3. Invoking a new process

```
procedure INVOKE_PROCESS
        (NODE:              in out NODE_TYPE;
         FILE_NODE:         in     NODE_TYPE;
         RESULTS_RETURNED:  in out RESULTS;
         STATUS:               out PROCESS_STATUS;
         INPUT_PARAMETERS:  in     PARAMETER_LIST;
         KEY:               in     RELATIONSHIP_KEY := LATEST_KEY;
         RELATION:          in     RELATION_NAME:=DEFAULT_RELATION;
```

```
                    ACCESS_CONTROL:     in      LIST_TYPE := EMPTY_LIST;
                    LEVEL:              in      LIST_TYPE := EMPTY_LIST;
                    ATTRIBUTES:         in      LIST_TYPE   := EMPTY_LIST;
                    INPUT_FILE:         in      NAME_STRING := CURRENT_INPUT;
                    OUTPUT_FILE:        in      NAME_STRING := CURRENT_OUTPUT;
                    ERROR_FILE:         in      NAME_STRING := CURRENT_ERROR;
                    ENVIRONMENT_NODE:   in      NAME_STRING := CURRENT_NODE;
                    TIME_LIMIT:         in      DURATION := DURATION'LAST);
```

Purpose:

This procedure provides the functionality described by the following Ada fragment except that the implementation must guarantee that only exceptions raised by the call to SPAWN_PROCESS in this fragment are raised by INVOKE_PROCESS.

```
SPAWN_PROCESS (NODE, FILE_NODE, INPUT_PARAMETERS, KEY, RELATION,
               ACCESS_CONTROL, LEVEL, ATTRIBUTES, INPUT_FILE,
               OUTPUT_FILE, ERROR_FILE, ENVIRONMENT_NODE);
AWAIT_PROCESS_COMPLETION (NODE, TIME_LIMIT);
GET_RESULTS (NODE, RESULTS_RETURNED);
STATUS := STATUS_OF_PROCESS (NODE);
```

Parameters:

NODE is a node handle returned open on the newly created process node.

FILE_NODE is an open node handle on the file node containing the executable image whose execution will be represented by the new process.

RESULTS_RETURNED
is a list of results which are represented by strings from the new process. The individual results may be extracted from the list using the tools of CAIS.LIST_UTILITIES.

STATUS gives the process status of the process. If termination or abortion of the identified process can be reported within the specified time limit, STATUS will have the value ABORTED or TERMINATED. If the process does not terminate or abort within the time limit, STATUS will have the value READY or SUSPENDED.

INPUT_PARAMETERS
is a list containing process parameter information. The list is constructed and parsed using the list handling tools of CAIS.LIST_UTILITIES. The value of INPUT_PARAMETERS is stored in the predefined attribute PARAMETERS of the new node.

KEY is the relationship key of the primary relationship from the current process node to the new process node. The default is supplied by the mechanism of interpreting the LATEST_KEY constant.

RELATION is the relation name of the primary relationship from the current process node to the new node. The default is DEFAULT_RELATION.

ACCESS_CONTROL
is a string defining the initial access control information associated with the created node.

LEVEL is a string defining the classification label for the created node (see TABLE IV).

ATTRIBUTES is a list which can be used to set attributes of the new node. It could be used by an implementation to establish allocation of resources.

INPUT_FILE, OUTPUT_FILE, ERROR_FILE
are pathnames to file nodes.

ENVIRONMENT_NODE
is the node the new process will have as its current node.

TIME_LIMIT is the limit on the time that the calling task will be suspended awaiting the new process. When the limit is exceeded, the calling task resumes execution. The default is the implementation dependent maximum value for DURATION.

Exceptions:

NAME_ERROR
is raised if a node already exists for the relationship specified by KEY and RELATION. NAME_ERROR is also raised if any of the nodes identified by INPUT_FILE, OUTPUT_FILE, ERROR_FILE or ENVIRONMENT NODE do not exist. It is also raised if KEY or RELATION is syntactically illegal or if any node identifying a group specified in the given ACCESS_CONTROL parameter is unobtainable or inaccessible.

USE_ERROR is raised if it can be determined that the node indicated by FILE_NODE does not contain an executable image. USE_ERROR is also raised if any of the parameters INPUT_PARAMETERS, LEVEL, ACCESS_CONTROL, or ATTRIBUTES is syntactically or semantically illegal. USE_ERROR is also raised if RELATION is the name of a predefined relation or if the ATTRIBUTES parameter contains references to a predefined attribute which cannot be modified or created by the user.

STATUS_ERROR
is raised if NODE is an open node handle prior to the call or if FILE_NODE is not an open node handle.

LOCK_ERROR
is raised if access with intent APPEND_RELATIONSHIPS cannot be obtained to the current process node due to an existing lock on the node.

INTENT_VIOLATION
is raised if the node designated by FILE_NODE was not opened with an intent establishing the right to execute contents.

Notes:

Both control and data (results and status) are returned to the calling task upon termination or abortion of the invoked process or when the TIME_LIMIT is exceeded.

5.2.2.4. Creating a new job

```
procedure CREATE_JOB
        (FILE_NODE:          in NODE_TYPE;
         INPUT_PARAMETERS:   in PARAMETER_LIST:=EMPTY_LIST;
         KEY:                in RELATIONSHIP_KEY := LATEST_KEY;
         ACCESS_CONTROL:     in LIST_TYPE := EMPTY_LIST;
         LEVEL:              in LIST_TYPE := EMPTY_LIST;
         ATTRIBUTES:         in LIST_TYPE  := EMPTY_LIST;
         INPUT_FILE:         in NAME_STRING := CURRENT_INPUT;
         OUTPUT_FILE:        in NAME_STRING := CURRENT_OUTPUT;
         ERROR_FILE:         in NAME_STRING := CURRENT_ERROR;
         ENVIRONMENT_NODE:   in NAME_STRING := CURRENT_USER);
```

Purpose:

This procedure creates a new root process node whose contents represent the execution of the program contained in the specified file node. Control returns to the calling task after the new job is created. The process node containing the calling task must have execution rights for the file node and sufficient rights to append relationships to the node identified by "'CURRENT_USER". A new primary relationship of the predefined relation JOB is established from the current user node to the root process node of the new job. The new root process as a subject can acquire all discretionary access rights to its own process node (the object). Secondary relationships emanating from the new process node are created and inherited as described in TABLE VI.

The ACCESS_CONTROL parameter specifies the initial access control information to be established for the created node. If the CAIS models of discretionary and mandatory access control are used, then, in addition to the relationships established using the information in the ACCESS_CONTROL parameter, an access relationship is established from the created process node to the current user node, with a GRANT attribute value ((READ, WRITE, CONTROL)).

The LEVEL parameter specifies the security level at which the node is to be created.

Parameters:

FILE_NODE — is an open node handle on the file node containing the executable image whose execution will be represented by the new process.

INPUT_PARAMETERS
is a list containing process parameter information. The list is constructed and parsed using the tools provided in CAIS.LIST_UTILITIES. INPUT_PARAMETERS is stored in the predefined attribute PARAMETERS of the new node.

KEY — is the relationship key of the primary relationship of the predefined relation JOB from the current user node to the new process node. The default is supplied by the mechanism of interpreting the LATEST_KEY constant.

ACCESS_CONTROL
is a string defining the initial access control information associated with the created node.

LEVEL — is a string defining the classification label for the created node (see TABLE IV).

ATTRIBUTES is a list which can be used to set attributes of the new node. It could be used by an implementation to establish allocation of resources.

INPUT_FILE, OUTPUT_FILE, ERROR_FILE
are pathnames to file nodes.

ENVIRONMENT_NODE
is the node the new process will have as its initial current node.

Exceptions:

NAME_ERROR
is raised if a node already exists for the relationship specified by KEY and the relation JOB. NAME_ERROR is also raised if any of the nodes identified by INPUT_FILE, OUTPUT_FILE, ERROR_FILE or ENVIRONMENT NODE does not exist. It is also raised if KEY is syntactically illegal or if any node identifying a group specified in the ACCESS_CONTROL parameter is unobtainable or inaccessible.

USE_ERROR is raised if it can be determined that the node indicated by FILE_NODE does not contain an executable image. USE_ERROR is also raised if any of the parameters INPUT_PARAMETERS, LEVEL, ACCESS_CONTROL, or ATTRIBUTES is syntactically or semantically illegal. USE_ERROR is also raised if the ATTRIBUTES parameter contains references to a predefined attribute which cannot be modified or created by the user.

STATUS_ERROR
is raised if FILE_NODE is not an open node handle.

LOCK_ERROR
is raised if access to the current user node or the current process node with intent APPEND_RELATIONSHIPS cannot be obtained due to an existing lock on the node.

INTENT_VIOLATION
is raised if the node designated by FILE_NODE was not opened with an intent establishing the right to execute contents.

ACCESS_VIOLATION
is raised if the current process does not have sufficient discretionary access rights to open the current user node with APPEND_RELATIONSHIPS intent. ACCESS_VIOLATION is raised only if the conditions for raising NAME_ERROR are not satisfied.

SECURITY_VIOLATION
is raised if the attempt to obtain access to the node identified by CURRENT_USER represents a violation of mandatory access controls for the CAIS. SECURITY_VIOLATION is raised only if the conditions for raising the other exceptions are not satisfied.

Notes:

CREATE_JOB does not return results or process status to the calling program unit. If coordination between any program unit and the new process is desired, AWAIT_PROCESS_COMPLETION or the techniques provided in CAIS input and output (see Section 5.3) must be used.

The relation name for the primary relationship to the new node is JOB.

5.2.2.5. Appending results

```
procedure APPEND_RESULTS(RESULTS: in RESULTS_STRING);
```

Purpose:

This procedure inserts the value of its RESULTS parameter as the last item in to the list which is the value of the RESULTS attribute of the current process node.

Parameters:

RESULTS — is a string to be appended to the RESULTS attribute value of the current process node.

Exceptions:

LOCK_ERROR
is raised if access with intent WRITE_ATTRIBUTES to the current process node cannot be obtained due to an existing lock on the node.

5.2.2.6. Overwriting results

```
procedure WRITE_RESULTS (RESULTS: in RESULTS_STRING);
```

Purpose:

This procedure replaces the value of the RESULTS attribute of the current process node with a list containing a single item which is the value of the parameter RESULTS.

Parameters:

RESULTS — is a string to be stored in the RESULTS attribute of the current process node.

Exceptions:

LOCK_ERROR
is raised if access with intent WRITE_ATTRIBUTES to the current process node cannot be obtained due to an existing lock on the node.

5.2.2.7. Getting results from a process

```
procedure GET_RESULTS(NODE:     in     NODE_TYPE;
                      RESULTS:  in out RESULTS_LIST);
```

Purpose:

This procedure returns the value of the attribute RESULTS of the process node identified by NODE. The process need not have terminated or aborted. The empty list is returned in RESULTS if WRITE_RESULTS or APPEND_RESULTS has not been called by the process contained in the node identified by NODE.

Parameters:

NODE — is an open node handle on a process node.

RESULTS — is an unnamed list of strings which returns the value of the RESULTS attribute of the process node identified by NODE. The individual strings may be extracted from the list using the tools of CAIS.LIST_UTILITIES (see Section 5.4).

Exceptions:

USE_ERROR is raised if the node identified by NODE is not a process node.

STATUS_ERROR
is raised if NODE is not an open node handle.

INTENT_VIOLATION
is raised if the NODE was not opened with an intent establishing the right to read attributes.

Additional Interfaces:

```
procedure GET_RESULTS(NODE:    in     NODE_TYPE;
                      RESULTS: in out RESULTS_LIST;
                      STATUS:     out PROCESS_STATUS)
is
begin
   GET_RESULTS(NODE, RESULTS);
   STATUS:=STATUS_OF_PROCESS(NODE);
end GET_RESULTS;

procedure GET_RESULTS(NAME:    in     NAME_STRING;
                      RESULTS: in out RESULTS_LIST;
                      STATUS:     out PROCESS_STATUS)
is
   NODE: NODE_TYPE;
begin
   OPEN(NODE, NAME, (1=>READ_ATTRIBUTES));
   GET_RESULTS(NODE, RESULTS);
   STATUS:=STATUS_OF_PROCESS(NODE);
   CLOSE(NODE);
exception
   when others =>
      CLOSE(NODE);
      raise;
end GET_RESULTS;

procedure GET_RESULTS(NAME:    in     NAME_STRING;
                      RESULTS: in out RESULTS_LIST)
is
   NODE: NODE_TYPE;
begin
   OPEN(NODE, NAME, (1=>READ_ATTRIB  ES));
   GET_RESULTS(NODE, RESULTS);
   CLOSE(NODE);
exception
   when others =>
      CLOSE(NODE);
      raise;
end GET_RESULTS;
```

5.2.2.8. Determining the status of a process

```
function STATUS_OF_PROCESS(NODE: in NODE_TYPE)
        return PROCESS_STATUS;
```

Purpose:

This function returns the current status of the process represented by NODE. It returns the value of the attribute CURRENT_STATUS associated with the process node identified by NODE.

Parameters:

NODE is an open node handle identifying the node of the process whose status is to be queried.

Exceptions:

USE_ERROR is raised if the node identified by NODE is not a process node.

STATUS_ERROR
is raised if NODE is not an open node handle.

INTENT_VIOLATION
is raised if the node handle NODE was not opened with an intent establishing the right to read attributes.

Additional Interface:

```
function STATUS_OF_PROCESS(NAME: in NAME_STRING)
        return PROCESS_STATUS
is
   NODE: NODE_TYPE;
   RESULT: PROCESS_STATUS;
begin
   OPEN(NODE, NAME, (1=>READ_ATTRIBUTES));
   RESULT := STATUS_OF_PROCESS(NODE);
   CLOSE(NODE);
   return RESULT;
exception
   when others =>
      CLOSE(NODE);
      raise;
end STATUS_OF_PROCESS;
```

5.2.2.9. Getting the parameter list

```
procedure GET_PARAMETERS(PARAMETERS: in out PARAMETER_LIST);
```

Purpose:

This procedure returns the value of the predefined attribute PARAMETERS of the current process node.

Parameters:

PARAMETERS

is a list containing parameter information. The list is constructed and can be manipulated using the tools provided in CAIS.LIST_UTILITIES.

Exceptions:

LOCK_ERROR
is raised if access with intent READ_ATTRIBUTES to the current process node cannot be obtained due to an existing lock on the node.

Notes:

The value of the predefined attribute PARAMETERS is set during process node creation; see the interfaces SPAWN_PROCESS, INVOKE_PROCESS and CREATE_JOB.

5.2.2.10. Aborting a process

```
procedure ABORT_PROCESS(NODE:    in NODE_TYPE;
                        RESULTS: in RESULTS_STRING);
```

Purpose:

This procedure aborts the process represented by NODE and forces any processes in the subtree rooted at the identified process to be aborted. The order of the process abortions is not specified. If the state of the process represented by NODE after return of ABORT_PROCESS is examined, it will be ABORTED or TERMINATED; it will be TERMINATED only if the process terminated before ABORT_PROCESS took effect. The node associated with the aborted process remains until explicitly deleted. If an exception is raised, none of the processes are aborted.

Parameters:

NODE is an open node handle for the node of the process to be aborted.

RESULTS is a string to be appended to the RESULTS attribute of the node represented by NODE.

Exceptions:

USE_ERROR is raised if the node identified by NODE is not a process node.

STATUS_ERROR
is raised if NODE is not an open node handle.

INTENT_VIOLATION
is raised if the node was not opened with an intent establishing rights to read relationships and to write attributes and contents.

ACCESS_VIOLATION
is raised if the current process does not have sufficient discretionary access control rights to obtain access to any node of a process to be aborted with intent including READ_RELATIONSHIPS, WRITE_ATTRIBUTES and WRITE_CONTENTS.

SECURITY_VIOLATION
is raised if the attempt to obtain access to the node identified by NODE represents

a violation of mandatory access controls in the CAIS. SECURITY_VIOLATION is raised only if the conditions for raising the other exceptions are not satisfied.

Additional Interfaces:

```
procedure ABORT_PROCESS(NAME:    in NAME_STRING;
                        RESULTS: in RESULTS_STRING)
is
   NODE: NODE_TYPE;
begin
   OPEN(NODE, NAME, (READ_RELATIONSHIPS, WRITE_CONTENTS,
                     WRITE_ATTRIBUTES));
   ABORT_PROCESS(NODE, RESULTS);
   CLOSE(NODE);
exception
   when others =>
      CLOSE(NODE);
      raise;
end ABORT_PROCESS;

procedure ABORT_PROCESS(NODE: in NODE_TYPE)
is
begin
   ABORT_PROCESS(NODE,"ABORTED");
end ABORT_PROCESS;

procedure ABORT_PROCESS(NAME: in NAME_STRING)
is
   NODE: NODE_TYPE;
begin
   OPEN(NODE, NAME, (READ_RELATIONSHIPS,WRITE_CONTENTS,WRITE_ATTRIBUTES));
   ABORT_PROCESS(NODE,"ABORTED");
   CLOSE(NODE);
exception
   when others =>
      CLOSE(NODE);
      raise;
end ABORT_PROCESS;
```

Notes:

ABORT_PROCESS can be used by a task to abort the process that contains it. It is intentional that LOCK_ERROR will not be raised by this procedure.

5.2.2.11. Suspending a process

```
procedure SUSPEND_PROCESS(NODE: in NODE_TYPE);
```

Purpose:

This procedure suspends the process represented by NODE. After SUSPEND_PROCESS is called, the CURRENT_STATUS of the identified process is SUSPENDED, provided that the process was in the READY status at the time that the suspension took effect. SUSPEND_PROCESS does not change the process status if the process is not in the READY state. If the node identified by NODE is the parent of other process nodes, the other processes are likewise suspended if an exception is raised, none of the processes are suspended.

Parameters:

NODE — is an open node handle identifying the node of the process to be suspended

Exceptions:

USE_ERROR is raised if the node identified by NODE is not a process node.

STATUS_ERROR
is raised if NODE is not an open node handle.

INTENT_VIOLATION
is raised if the node handle NODE was not opened with an intent establishing rights to read relationships and to write attributes and contents.

ACCESS_VIOLATION
is raised if the current process does not have sufficient discretionary access rights to obtain access to any node of a process to be suspended with intent including READ_RELATIONSHIPS, WRITE_ATTRIBUTES and WRITE_CONTENTS.

SECURITY_VIOLATION
is raised if the attempt to obtain access to the node identified by NODE represents a violation of the mandatory access controls for the CAIS. SECURITY_VIOLATION is raised only if conditions for raising the other exceptions are not satisfied.

Additional Interface:

```
procedure SUSPEND_PROCESS(NAME: in NAME_STRING)
is
   NODE: NODE_TYPE;
begin
   OPEN(NODE, NAME, (READ_RELATIONSHIPS, WRITE_ATTRIBUTES,
                     WRITE_CONTENTS));
   SUSPEND_PROCESS(NODE);
   CLOSE(NODE);
exception
   when others =>
      CLOSE(NODE);
      raise;
end SUSPEND_PROCESS;
```

Notes:

SUSPEND_PROCESS can be used by a task to suspend the process that contains it.

5.2.2.12. Resuming a process

```
procedure RESUME_PROCESS(NODE: in NODE_TYPE);
```

Purpose:

This procedure causes the process represented by NODE to resume execution. RESUME_PROCESS does not change the process status if the process is not suspended. After RESUME_PROCESS is called, the PROCESS_STATUS of the identified process is READY provided that the process was in the SUSPENDED status at the time that the resumption took effect. If the node identified by NODE is the parent of other process nodes, the other processes are likewise resumed. If an exception is raised, none of the processes is resumed.

Parameters:

NODE is an open node handle identifying the node of the process to be resumed.

Exceptions:

USE_ERROR is raised if the node identified by NODE is not a process node.

STATUS_ERROR
is raised if NODE is not an open node handle.

INTENT_VIOLATION
is raised if the node handle NODE was not opened with an intent establishing rights to read relationships and to write attributes and contents.

ACCESS_VIOLATION
is raised if the current process does not have sufficient discretionary access rights to obtain access to any node of a process to be suspended with intent including READ_RELATIONSHIPS, WRITE_ATTRIBUTES and WRITE_CONTENTS.

SECURITY_VIOLATION
is raised if the attempt to obtain access to the node identified by NODE represents a violation of the mandatory access controls for the CAIS. SECURITY_VIOLATION is raised only if the conditions for raising the other exceptions are not satisfied.

Additional Interface:

```
procedure RESUME_PROCESS(NAME: in NAME_STRING)
is
   NODE: NODE_TYPE;
begin
   OPEN(NODE, NAME, (READ_RELATIONSHIPS, WRITE_ATTRIBUTES,
                      WRITE_CONTENTS));
   RESUME_PROCESS(NODE);
   CLOSE(NODE);
exception
   when others =>
      CLOSE(NODE);
      raise;
end RESUME_PROCESS;
```

5.2.2.13. Determining the number of open node handles

```
function HANDLES_OPEN (NODE : in NODE_TYPE)
      return NATURAL;
```

Purpose:

This function returns a natural number representing the value of the predefined attribute HANDLES_OPEN of the process node identified by NODE.

Parameters:

NODE is an open node handle identifying the process node whose attribute is being queried.

Exceptions:

USE_ERROR is raised if the node identified by NODE is not a process node.

STATUS_ERROR
is raised if NODE is not an open node handle.

INTENT_VIOLATION
is raised if the node handle NODE was not opened with an intent establishing the right to read attributes.

Additional Interface:

```
function HANDLES_OPEN (NAME : in NAME_STRING)
        return NATURAL
is
   NODE: NODE_TYPE;
   RESULT: NATURAL;
begin
   OPEN(NODE, NAME, (1=>READ_ATTRIBUTES));
   RESULT := HANDLES_OPEN(NODE);
   CLOSE(NODE);
   return RESULT;
exception
   when others =>
      CLOSE(NODE);
      raise;
end HANDLES_OPEN;
```

5.2.2.14. Determining the number of input and output units used

```
function IO_UNITS (NODE : in NODE_TYPE)
        return NATURAL;
```

Purpose:

This function returns a natural number representing the value of the predefined attribute IO_UNITS of the process node identified by NODE.

Parameters:

NODE is an open node handle identifying the process node whose attribute is being queried.

Exceptions:

USE_ERROR is raised if the node identified by NODE is not a process node.

STATUS_ERROR
is raised if NODE is not an open node handle.

LOCK_ERROR
is raised if the node is locked against reading attributes.

INTENT_VIOLATION

is raised if the node handle was not opened with an intent establishing the right to read attributes.

Additional Interface:

```
function IO_UNITS (NAME : in NAME_STRING)
        return NATURAL
is
   NODE: NODE_TYPE;
   RESULT: NATURAL;
begin
   OPEN(NODE, NAME, (1=>READ_ATTRIBUTES));
   RESULT := IO_UNITS(NODE);
   CLOSE(NODE);
   return RESULT;
exception
   when others =>
      CLOSE(NODE);
      raise;
end IO_UNITS;
```

5.2.2.15. Determining the time of activation

```
function START_TIME (NODE : in NODE_TYPE)
        return TIME;
```

Purpose:

This function returns a value of type TIME representing the value of the predefined attribute START_TIME of the process node identified by NODE.

Parameters:

NODE is an open node handle identifying the process node whose attribute is being queried.

Exceptions:

USE_ERROR is raised if the node identified by NODE is not a process node.

STATUS_ERROR
is raised if NODE is not an open node handle.

LOCK_ERROR
is raised if the node is locked against reading attributes.

INTENT_VIOLATION
is raised if the node handle NODE was not opened with an intent establishing the right to read attributes.

Additional Interface:

```
function START_TIME (NAME : in NAME_STRING)
        return TIME
is
   NODE: NODE_TYPE;
```

```
   RESULT: TIME;
begin
   OPEN(NODE, NAME, (1=>READ_ATTRIBUTES));
   RESULT := START_TIME(NODE);
   CLOSE(NODE);
   return RESULT;
exception
   when others =>
      CLOSE(NODE);
      raise;
end START_TIME;
```

5.2.2.16. Determining the time of termination or abortion

```
function FINISH_TIME (NODE : in NODE_TYPE)
      return TIME;
```

Purpose:

This function returns a value of type TIME representing the value of the predefined attribute FINISH_TIME of the process node identified by NODE.

Parameters:

NODE is an open node handle identifying the process node whose attribute is being queried.

Exceptions:

USE_ERROR is raised if the node identified by NODE is not a process node.

STATUS_ERROR
is raised if NODE is not an open node handle.

INTENT_VIOLATION
is raised if the node handle NODE was not opened with an intent establishing the right to read attributes.

Additional Interface:

```
function FINISH_TIME (NAME : in NAME_STRING)
      return TIME
is
   NODE: NODE_TYPE;
   RESULT: TIME;
begin
   OPEN(NODE, NAME, (1=>READ_ATTRIBUTES));
   RESULT := FINISH_TIME(NODE);
   CLOSE(NODE);
   return RESULT;
exception
   when others =>
      CLOSE(NODE);
      raise;
end FINISH_TIME;
```

5.2.2.17. Determining the time a process has been active

```
function MACHINE_TIME (NODE : in NODE_TYPE)
        return DURATION;
```

Purpose:

This function returns a value of type DURATION representing the value of the predefined attribute MACHINE_TIME of the process node identified by NODE.

Parameters:

NODE is an open node handle identifying the process node whose attribute is being queried.

Exceptions:

USE_ERROR is raised if the node identified by NODE is not a process node.

STATUS_ERROR
is raised if NODE is not an open node handle.

INTENT_VIOLATION
is raised if the node handle NODE was not opened with an intent establishing the right to read attributes.

Additional Interface:

```
function MACHINE_TIME (NAME : in NAME_STRING)
        return DURATION
is
   NODE: NODE_TYPE;
   RESULT: DURATION;
begin
   OPEN(NODE, NAME, (1=>READ_ATTRIBUTES));
   RESULT := MACHINE_TIME(NODE);
   CLOSE(NODE);
   return RESULT;
exception
   when others =>
      CLOSE(NODE);
      raise;
end MACHINE_TIME;
```

5.3. CAIS input and output

The CAIS defines four kinds of files: secondary storage files, queue files, terminal files and magnetic tape drive files. CAIS files are supported by CAIS input and output packages as described in TABLE VIII.

Table VIII. Input and output packages for file kinds

	Secondary Storage	Queue	Terminal	Magnetic Tape
CAIS.IO_CONTROL	X	X	X	X
CAIS.IO_DEFINITIONS	X	X	X	X
CAIS.SEQUENTIAL_IO	X	X		
CAIS.DIRECT_IO	X			
CAIS.TEXT_IO	X	X	X	X
CAIS.SCROLL_TERMINAL			X	
CAIS.PAGE_TERMINAL			X	
CAIS.FORM_TERMINAL			X	
CAIS.MAGNETIC_TAPE				X

A secondary storage file in the CAIS represents a disk or other random access storage file. Secondary storage files may be created by use of the CREATE procedures specified in the packages CAIS.SEQUENTIAL_IO, CAIS.DIRECT_IO, and CAIS.TEXT_IO.

A *queue* file in the CAIS represents a sequence of information that is accessed in a first-in, first-out manner. There are three kinds of CAIS queue files: solo, copy and mimic. A solo queue operates like a simple queue, initially empty, in which all writes append information to the end and all reads are destructive. A copy queue operates like a solo queue except that it has initial contents which are copied from another file; after the creation of the copy queue, it is independent of the file. A mimic queue operates like a solo queue except that it has initial contents that are the same as the contents of another file; after the creation of the mimic queue, the mimic queue and the file are mutually dependent. This means that, if information is written to the mimic queue file, it is appended to the other file as well at an implementation defined time which is no later than CLOSE of the mimic queue file; the effect on the mimic queue file of writing or appending to the other file is implementation defined. Solo queue files may be created by use of the CREATE procedures in the packages CAIS.SEQUENTIAL_IO and CAIS.TEXT_IO. Copy and mimic queue files may be created by use of the COUPLE procedure in the package IO_CONTROL.

A terminal file in the CAIS represents an interactive terminal device. Three kinds of terminal devices are distinguished in the CAIS: scroll, page and form. These are distinguished because they have different characteristics which require specialized interfaces. Scroll and page terminals may be represented either by a single terminal file for input and output or by two terminal files, one for input and one for output. The implementation determines, for each physical terminal, whether it will be represented by one or two terminal files. If two terminal files are used to represent the terminal input and output, then the implementation maintains an implicit association between the two files. A form terminal is represented by a single terminal file for both input and output.

A magnetic tape drive file in the CAIS represents a magnetic tape drive. Operations on magnetic tape drive files can affect either the magnetic tape or the drive. Interfaces must be provided outside the CAIS for the creation of terminal files and magnetic tape drive files.

Several predefined attributes are applicable to file nodes. The attributes ACCESS_METHOD, FILE_KIND, QUEUE_KIND, and TERMINAL_KIND provide information about the contents of a file node and how it may be accessed.

It is possible that a single file node may have more than one access method, as specified by the predefined attribute ACCESS_METHOD. The value of the attribute ACCESS_METHOD determines the packages that may operate upon the file. The predefined values for the attribute ACCESS_METHOD are SEQUENTIAL, DIRECT, and TEXT or any list combination of these. A value of SEQUENTIAL indicates that the CAIS.SEQUENTIAL_IO package may be used. A value of DIRECT indicates that the package CAIS.DIRECT_IO may be used. A value of TEXT indicates that the package CAIS.TEXT_IO may be used.

The attribute FILE_KIND denotes the kind of file that is represented by the contents of the file node. The predefined values for the attribute FILE_KIND are SECONDARY_STORAGE, QUEUE, TERMINAL, and MAGNETIC_TAPE. These values determine which packages may be used to operate on files, as shown in TABLE VIII.

File nodes with a FILE_KIND value of QUEUE also have a predefined attribute QUEUE_KIND. The predefined values for the attribute QUEUE_KIND are SOLO, MIMIC, and COPY.

File nodes with a FILE_KIND value of TERMINAL also have a predefined attribute TERMINAL_KIND. The values SCROLL, PAGE, and FORM are predefined for this attribute. In addition, terminal file nodes will have a value of TEXT for the attribute ACCESS_METHOD.

When a QUEUE file node is created with QUEUE_KIND of COPY or MIMIC, a relationship of the predefined relation COUPLE is established from the QUEUE node to the file node which provides the queue's initial contents.

The above discussion is summarized in TABLE IX.

Table IX. File node predefined attributes, attribute values and relation

	Secondary Storage	Queue	Terminal	Magnetic Tape
ACCESS_METHOD	A	A	A	A
SEQUENTIAL	V	V		
DIRECT	V			
TEXT	V	V	V	V
FILE_KIND	A	A	A	A
SECONDARY STORAGE	V			
QUEUE		V		
TERMINAL			V	
MAGNETIC TAPE				V
QUEUE_KIND		A		
SOLO		V		
MIMIC		V		
COPY		V		
TERMINAL_KIND			A	
SCROLL			V	
PAGE			V	
FORM			V	
COUPLE		A		

A = an attribute or relation which applies to the file node
V = an attribute value which the attribute can have for the file node.

The input and output operations in the packages in this section are expressed as operations on objects of some file type, rather than directly in terms of the external files. These objects are files which are internal to a CAIS process (*internal files*). Internal files are identified by *file handles*. Throughout this document, the word *file* is used to mean an Ada external file, while in the [LRM] the word file is used to mean an internal file. The mode of a file determines the intents with which its associated file node can be opened. These corresponding modes and intents are given in TABLE X.

Table X. Modes and intents

If the MODE is:	the INTENT must establish the right to:
IN_FILE	read contents
OUT_FILE	write contents
INFILE	read and write contents
APPEND_FILE	append contents

5.3.1. Package IO_DEFINITIONS

This package defines the types and exceptions associated with file nodes.

```
type CHARACTER_ARRAY is array(CHARACTER) of BOOLEAN;

type FILE_MODE is (IN_FILE, INOUT_FILE, OUT_FILE, APPEND_FILE);

type FILE_TYPE is limited private;

type FUNCTION_KEY_DESCRIPTOR(LENGTH: POSITIVE) is private;

type TAB_ENUMERATION is (HORIZONTAL, VERTICAL);

type POSITION_TYPE is
    record
        ROW    : NATURAL;
        COLUMN : NATURAL;
    end record;
```

CHARACTER_ARRAY provides information concerning the characters that can be obtained during a GET operation. FILE_MODE indicates the type of operations that are to be permitted on a file. Analogous to the [LRM] type FILE_TYPE and the CAIS type NODE_TYPE, the CAIS provides a type FILE_TYPE whose values are references to internal files. FILE_TYPE is used for controlling the operations on all files. FUNCTION_KEY_DESCRIPTOR is used to determine the function keys entered from a terminal. TAB_ENUMERATION is used to specify the kind of tab stop to be set. POSITION_TYPE is used to specify a position on a terminal.

This package also provides the definitions for all exceptions generated by the input and output packages. These definitions are comparable to those specified in the package IO_EXCEPTIONS in the [LRM].

5.3.2. Package DIRECT_IO

This package provides facilities for direct-access input and output to CAIS files comparable to those described in the DIRECT_IO package of [LRM]. Files written with the CAIS.DIRECT_IO are also readable by CAIS.SEQUENTIAL_IO, if the two packages are instantiated with the same generic data type.

The package specification and semantics of the CAIS.DIRECT_IO are comparable to those of the [LRM] package DIRECT_IO. All subprograms present in the [LRM] package DIRECT_IO are present in this CAIS package. The following sections demonstrate only the specifications and semantics that differ.

5.3.2.1. Subtypes and constants

```
subtype FILE_TYPE is CAIS.IO_DEFINITIONS.FILE_TYPE;

subtype FILE_MODE is CAIS.IO_DEFINITIONS.FILE_MODE;

IN_FILE    : constant FILE_MODE := CAIS.IO_DEFINITIONS.IN_FILE;
INOUT_FILE : constant FILE_MODE := CAIS.IO_DEFINITIONS.INOUT_FILE;
OUT_FILE   : constant FILE_MODE := CAIS.IO_DEFINITIONS.OUT_FILE;
```

FILE_TYPE describes the type for file handles for all direct input and output operations.

FILE_MODE indicates whether input operations, output operations or both can be performed on the direct-access file.

5.3.2.2. Creating a direct input or output file

```
procedure CREATE(FILE:           in out FILE_TYPE;
                 BASE:           in     NODE_TYPE;
                 KEY:            in     RELATIONSHIP_KEY :=
                                        LATEST_KEY;
                 RELATION:       in     RELATION_NAME :=
                                        DEFAULT_RELATION;
                 MODE:           in     FILE_MODE := INOUT_FILE;
                 FORM:           in     LIST_TYPE := EMPTY_LIST;
                 ATTRIBUTES:     in     LIST_TYPE := EMPTY_LIST;
                 ACCESS_CONTROL: in     LIST_TYPE := EMPTY_LIST;
                 LEVEL:          in     LIST_TYPE := EMPTY_LIST);
```

Purpose:

This procedure creates a file and its file node; each element of the file is directly addressable by an index. The [LRM] defines what constitutes an *element*. The attribute ACCESS_METHOD is assigned the value "(DIRECT, SEQUENTIAL)" as part of the creation.

The FORM parameter is used to provide file characteristics concerning the creation of the file. The predefined file characteristic ESTIMATED_SIZE may be used to specify an approximation to the number of storage units (i.e, bytes or blocks) that should be writable to the file. The ESTIMATED_SIZE characteristic is specified as "(ESTIMATED_SIZE => n)", where "n" is any NATURAL number.

The ATTRIBUTES parameter defines and provides initial values for attributes of the node. The ACCESS_CONTROL parameter specifies initial access control information to be established for the created node (see Section 4.4.2.1 for details).

The LEVEL parameter specifies the security level at which the file node is to be created.

The value of the attribute FILE_KIND for the file node will be SECONDARY_STORAGE.

Parameters:

FILE — is a file handle, initially closed, to be opened.

BASE — is an open node handle to the node which will be the source of the primary relationship to the new node.

KEY — is the relationship key of the primary relationship to be created.

RELATION — is the relation name of the primary relationship to be created.

MODE — indicates the mode of the file.

FORM — indicates file characteristics.

ATTRIBUTES — defines initial values for attributes of the newly created node.

ACCESS_CONTROL
: defines the initial access control information associated with the created node.

LEVEL
: defines the classification label for the created node.

Exceptions:

NAME_ERROR
: is raised if a node already exists for the node specified by KEY and RELATION, if KEY or RELATION is syntactically illegal, or if any node identifying a group specified in the given ACCESS_CONTROL parameter is unobtainable or inaccessible.

USE_ERROR
: is raised if any of the parameters ACCESS_CONTROL, LEVEL or ATTRIBUTES is syntactically or semantically illegal. USE_ERROR is also raised if interpretation of the ATTRIBUTES parameter would result in modification or creation of any predefined attribute. USE_ERROR is also raised if RELATION is the name of a predefined relation that cannot be modified or created by the user.

STATUS_ERROR
: is raised if BASE is not an open node handle or if FILE is an open file handle prior to the call.

INTENT_VIOLATION
: is raised if BASE was not opened with an intent establishing the right to append relationships.

SECURITY_VIOLATION
: is raised if the operation represents a violation of mandatory access controls. SECURITY_VIOLATION is raised only if the conditions for other exceptions are not present.

Additional Interface:

```
procedure CREATE(FILE:           in out FILE_TYPE;
                 NAME:           in     NAME_STRING;
                 MODE:           in     FILE_MODE := INOUT_FILE;
                 FORM:           in     LIST_TYPE  := EMPTY_LIST;
                 ATTRIBUTES:     in     LIST_TYPE  := EMPTY_LIST;
                 ACCESS_CONTROL: in     LIST_TYPE  := EMPTY_LIST;
                 LEVEL:          in     LIST_TYPE  := EMPTY_LIST)
is
    BASE : NODE_TYPE;
begin
    OPEN(BASE, BASE_PATH(NAME), (1=>APPEND_RELATIONSHIPS));
    CREATE(FILE, BASE, LAST_KEY(NAME), LAST_RELATION(NAME),
           MODE, FORM, ATTRIBUTES, ACCESS_CONTROL, LEVEL);
    CLOSE(BASE);
exception
    when others =>
        CLOSE(FILE);
        CLOSE(BASE);
    raise;
end CREATE;
```

5.3.2.3. Opening a direct input or output file

```
procedure OPEN(FILE:   in  out FILE_TYPE;
               NODE:   in      NODE_TYPE;
               MODE:   in      FILE_MODE);
```

Purpose:

This procedure opens a file handle on a file, given an open node handle to the file node; each element of the file is directly addressable by an index.

Parameters:

FILE — is a file handle, initially closed, to be opened.

NODE — is an open node handle to the file node.

MODE — indicates the mode of the file.

Exceptions:

USE_ERROR is raised if the attribute ACCESS_METHOD of the file node does not have the value DIRECT, if the element type of the file does not correspond with the element type of this instantiation of the CAIS.DIRECT_IO package, or if the mode is APPEND_FILE.

STATUS_ERROR
is raised if FILE is an open file handle at the time of the call on OPEN or if NODE is not an open node handle.

INTENT_VIOLATION
is raised if NODE was not opened with an intent establishing the access rights required for the MODE, as specified in TABLE X.

Additional Interface:

```
procedure OPEN(FILE: in  out FILE_TYPE;
               NAME: in      NAME_STRING;
               MODE: in      FILE_MODE )
is
    NODE : NODE_TYPE;
begin
    case MODE is
       when IN_FILE => OPEN(NODE, NAME,(1=>READ_CONTENTS));
       when OUT_FILE => OPEN(NODE, NAME,(1=>WRITE_CONTENTS));
       when INOUT_FILE =>OPEN(NODE,NAME,
                              (READ_CONTENTS,WRITE_CONTENTS));
       when APPEND_FILE =>raise USE_ERROR;
    end case;
    OPEN(FILE, NODE, MODE)
    CLOSE(NODE);
exception
    when others =>
       CLOSE(FILE);
       CLOSE(NODE);
    raise;
end OPEN;
```

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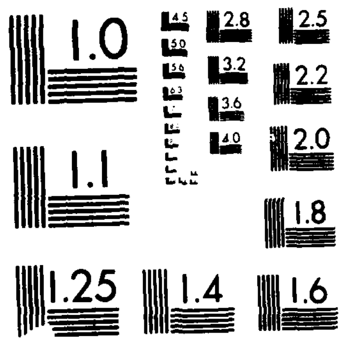
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1.6

Notes:

The effects on the open file handle of closing an open node handle on its node are implementation-defined. In particular, no assumption can be made about the access protection provided by the node model.

5.3.2.4. Deleting a direct input or output file

procedure DELETE(FILE:**in out** FILE_TYPE);

Purpose:

In addition to the semantics specified in [LRM], if the node associated with the open file handle FILE is not already unobtainable, this node is made unobtainable as if a call to the DELETE_NODE procedure had been made. If this node is already unobtainable by this call, no exception other than STATUS_ERROR may be raised by this procedure.

Parameters:

FILE is an open file handle on the file being deleted.

Exceptions:

NAME_ERROR
: is raised if the parent node of the node associated with the file identified by FILE is inaccessible.

USE_ERROR
: is raised if any primary relationships emanate from the node associated with the file identified by FILE.

STATUS_ERROR
: is raised if FILE is not an open file handle.

LOCK_ERROR
: is raised if access with intent WRITE_RELATIONSHIPS to the parent of the node to be deleted cannot be obtained due to an existing lock on the node.

ACCESS_VIOLATION
: is raised if the current process does not have sufficient discretionary access control rights to obtain access to the parent of the node to be deleted with intent WRITE_RELATIONSHIPS or to obtain access to the node to be deleted with intent EXCLUSIVE_WRITE. ACCESS_VIOLATION is only raised if the conditions for NAME_ERROR are not present.

SECURITY_VIOLATION
: is raised if the operation represents a violation of mandatory access controls. SECURITY_VIOLATION is raised only if the conditions for other exceptions are not present.

5.3.3. Package SEQUENTIAL_IO

This package provides facilities for sequentially accessing data elements in CAIS files. [LRM] defines what constitutes an element. These facilities are comparable to those described in the SEQUENTIAL_IO package of [LRM].

The package specification and semantics of the CAIS.SEQUENTIAL_IO are comparable to those of the [LRM] package SEQUENTIAL_IO. All subprograms present in the [LRM] package SEQUENTIAL_IO are present in this CAIS package. The following sections demonstrate only the specifications and semantics that differ.

5.3.3.1. Subtypes and constants

```
subtype FILE_TYPE is CAIS.IO_DEFINITIONS.FILE_TYPE;

subtype FILE_MODE is CAIS.IO_DEFINITIONS.FILE_MODE;

IN_FILE     : constant FILE_MODE := CAIS.IO_DEFINITIONS.IN_FILE;
INOUT_FILE  : constant FILE_MODE := CAIS.IO_DEFINITIONS.INOUT_FILE;
OUT_FILE    : constant FILE_MODE := CAIS.IO_DEFINITIONS.OUT_FILE;
APPEND_FILE : constant FILE_MODE := CAIS.IO_DEFINITIONS.APPEND_FILE;
```

FILE_TYPE describes the type for file handles for all sequential input and output operations. FILE_MODE indicates whether input operations, output operations or both can be performed on the sequential-access file. A mode of APPEND_FILE causes any elements that are written to the specified file to be appended to the elements that are already in the file.

5.3.3.2. Creating a sequential input or output file

```
procedure CREATE(FILE:           in out FILE_TYPE;
                 BASE:           in     NODE_TYPE;
                 KEY:            in     RELATIONSHIP_KEY := LATEST_KEY;
                 RELATION:       in     RELATION_NAME :=
                                       DEFAULT_RELATION;
                 MODE:           in     FILE_MODE := INOUT_FILE;
                 FORM:           in     LIST_TYPE := EMPTY_LIST;
                 ATTRIBUTES:     in     LIST_TYPE := EMPTY_LIST;
                 ACCESS_CONTROL: in     LIST_TYPE := EMPTY_LIST;
                 LEVEL:          in     LIST_TYPE := EMPTY_LIST);
```

Purpose:

This procedure creates a file and its file node; each element of the file is sequentially accessible. The attribute ACCESS_METHOD is assigned the value "(SEQUENTIAL)" as part of the creation.

The FORM parameter is used to provide file characteristics concerning the creation of the file. The predefined file characteristic ESTIMATED_SIZE may be used to specify an approximation to the number of storage units (e.g., bytes or blocks) that should be writable to the file. The ESTIMATED_SIZE characteristic is specified as "(ESTIMATED_SIZE => n)", where "n" is any NATURAL number.

The ATTRIBUTES parameter defines and provides initial values for attributes of the node. The ACCESS_CONTROL parameter specifies initial access control information to be established for the created node (see Section 4.4.2.1 for details).

The LEVEL parameter specifies the security level at which the file node is to be created.

The default value for the attribute FILE_KIND for the file node is SECONDARY_STORAGE. The default value may be overridden by explicitly specifying a value of QUEUE in the attributes parameter (i.e., "(FILE_KIND => QUEUE)"), in which case the value of the attribute QUEUE_KIND is SOLO.

Parameters:

FILE — is a file handle, initially closed, to be opened.

BASE — is an open node handle to the node which will be the source of the primary relationship to the new node.

KEY — is the relationship key of the primary relationship to be created.

RELATION — is the relation name of the primary relationship to be created.

MODE — indicates the mode of the file.

FORM — indicates file characteristics.

ATTRIBUTES — defines initial values for attributes of the newly created node.

ACCESS_CONTROL — defines the initial access control information associated with the created node.

LEVEL — defines the classification label for the created node.

Exceptions:

NAME_ERROR — is raised if a node already exists for the node specified by KEY and RELATION or if KEY or RELATION is syntactically illegal or if any node identifying a group specified in the given ACCESS_CONTROL parameter is unobtainable or inaccessible.

USE_ERROR — is raised if any of the parameters ACCESS_CONTROL, LEVEL or ATTRIBUTES is syntactically or semantically illegal. USE_ERROR is also raised if interpretation of the ATTRIBUTES parameter would result in creation of any predefined attribute other than FILE_KIND. USE_ERROR is also raised if RELATION is the name of a predefined relation that cannot be created by the user.

STATUS_ERROR — is raised if BASE is not an open node handle or if FILE is an open file handle prior to the call.

INTENT_VIOLATION — is raised if BASE was not opened with an intent establishing the right to append relationships.

SECURITY_VIOLATION
is raised if the operation represents a violation of mandatory access controls. SECURITY_VIOLATION is raised only if the conditions for other exceptions are not present.

Additional Interface:

```
procedure CREATE(FILE:           in out FILE_TYPE;
                 NAME:           in     NAME_STRING;
                 MODE:           in     FILE_MODE := INOUT_FILE;
                 FORM:           in     LIST_TYPE := EMPTY_LIST;
                 ATTRIBUTES:     in     LIST_TYPE := EMPTY_LIST;
                 ACCESS_CONTROL: in     LIST_TYPE := EMPTY_LIST;
                 LEVEL:          in     LIST_TYPE := "")
is
    BASE : NODE_TYPE;
begin
    OPEN(BASE, BASE_PATH(NAME), (1=>APPEND_RELATIONSHIPS));
    CREATE(FILE, BASE, LAST_KEY(NAME), LAST_RELATION(NAME),
           MODE, FORM, ATTRIBUTES, ACCESS_CONTROL, LEVEL);
    CLOSE(BASE);
exception
    when others =>
        CLOSE(FILE);
        CLOSE(BASE);
    raise;
end CREATE;
```

5.3.3.3. Opening a sequential input or output file

```
procedure OPEN(FILE:  in out FILE_TYPE;
               NODE:  in     NODE_TYPE;
               MODE:  in     FILE_MODE);
```

Purpose:

This procedure opens a file handle on a file, given an open node handle on the file node; each element of the file is sequentially accessible.

Parameters:

FILE — is a file handle, initially closed, to be opened.

NODE — is an open node handle to the file node.

MODE — indicates the mode of the file.

Exceptions:

USE_ERROR is raised if the attribute ACCESS_METHOD of the file node does not have the value SEQUENTIAL or if the element type of the file does not correspond with the element type of this instantiation of the CAIS.SEQUENTIAL_IO package. USE_ERROR is also raised if the node identified by NODE has a value of QUEUE for the attribute FILE_KIND and a value of MIMIC for the attribute QUEUE_KIND and the mimic queue file identified by FILE is being opened with MODE other than IN_FILE but the coupled file (see Section 5.3.5.13) has been deleted.

STATUS_ERROR
is raised if FILE is an open file handle at the time of the call on OPEN or if NODE is not an open node handle.

INTENT_VIOLATION
is raised if NODE was not opened with an intent establishing the access rights required for the MODE, as specified in TABLE X.

Additional Interface:

```
procedure OPEN(FILE: in out FILE_TYPE;
               NAME: in     NAME_STRING;
               MODE: in     FILE_MODE )
is
    NODE : NODE_TYPE;
begin
    case MODE is
      when IN_FILE => OPEN(NODE, NAME,(1=>READ_CONTENTS));
      when OUT_FILE => OPEN(NODE, NAME,(1=>WRITE_CONTENTS));
      when INOUT_FILE=>OPEN(NODE,NAME,
                    (READ_CONTENTS,WRITE_CONTENTS));
      when APPEND_FILE => OPEN(NODE, NAME,(1=>APPEND_CONTENTS));
    end case;
    OPEN(FILE, NODE, MODE);
    CLOSE(NODE);
exception
    when others =>
        CLOSE(FILE);
        CLOSE(NODE);
    raise;
end OPEN;
```

5.3.3.4. Deleting a sequential input or output file

```
procedure DELETE(FILE:in out FILE_TYPE);
```

Purpose:

In addition to the semantics specified in [LRM], if the node associated with the open file handle FILE is not already unobtainable, this node is made unobtainable as if a call to the DELETE_NODE procedure had been made. If this node is already unobtainable by this call, no exception other than STATUS_ERROR may be raised by this procedure.

Parameters:

FILE is an open file handle on the file being deleted.

Exceptions:

NAME_ERROR
is raised if the parent node of the node associated with the file identified by FILE is inaccessible.

USE_ERROR is raised if any primary relationships emanate from the node associated with the file identified by FILE.

STATUS_ERROR
is raised if FILE is not open file handle.

LOCK_ERROR

is raised if access with intent WRITE_RELATIONSHIPS to the parent of the node to be deleted cannot be obtained due to an existing lock on the node.

ACCESS_VIOLATION

is raised if the current process does not have sufficient discretionary access control rights to obtain access to the parent of the node to be deleted with intent WRITE_RELATIONSHIPS or to obtain access to the node to be deleted with intent EXCLUSIVE_WRITE. ACCESS_VIOLATION is only raised if the conditions for NAME_ERROR are not present.

SECURITY_VIOLATION

is raised if the operation represents a violation of mandatory access controls. SECURITY_VIOLATION is raised only if the conditions for other exceptions are not present.

5.3.4. Package TEXT_IO

This package provides facilities for the input and output of textual data to CAIS files. [LRM] defines what constitutes an element of data. These facilities are comparable to those specified in the package TEXT_IO in [LRM]. All subprograms present in the [LRM] package TEXT_IO are present in this CAIS package. The following sections demonstrate only the specifications and semantics that differ.

5.3.4.1. Subtypes and constants

```
subtype FILE_TYPE is CAIS.IO_DEFINITIONS.FILE_TYPE;

subtype FILE_MODE is CAIS.IO_DEFINITIONS.FILE_MODE;

IN_FILE     : constant FILE_MODE := CAIS.IO_DEFINITIONS.IN_FILE;
INOUT_FILE  : constant FILE_MODE := CAIS.IO_DEFINITIONS.INOUT_FILE;
OUT_FILE    : constant FILE_MODE := CAIS.IO_DEFINITIONS.OUT_FILE;
APPEND_FILE : constant FILE_MODE := CAIS.IO_DEFINITIONS.APPEND_FILE;
```

FILE_TYPE describes the type for file handles for all text input and output operations. FILE_MODE indicates whether input operations, output operations or both can be performed on the text file. A mode of APPEND_FILE causes any text written to the specified file to be appended to the text that is already in the file.

5.3.4.2. Creating a text input or output file

```
procedure CREATE(FILE:           in out FILE_TYPE;
                 BASE:           in     NODE_TYPE;
                 KEY:            in     RELATIONSHIP_KEY := LATEST_KEY;
                 RELATION:       in     RELATION_NAME :=
                                         DEFAULT_RELATION;
                 MODE:           in     FILE_MODE := INOUT_FILE;
                 FORM:           in     LIST_TYPE := EMPTY_LIST;
                 ATTRIBUTES:     in     LIST_TYPE := EMPTY_LIST;
                 ACCESS_CONTROL: in     LIST_TYPE := EMPTY_LIST;
                 LEVEL:          in     LIST_TYPE := EMPTY_LIST);
```

Purpose:

This procedure creates a file and its file node; the file is textual. The attribute ACCESS_METHOD is assigned the value "(TEXT)" as part of the creation.

The FORM parameter is used to provide file characteristics concerning the creation of the external file. The predefined file characteristic ESTIMATED_SIZE may be used to specify an approximation to the number of storage units (e.g., bytes or blocks) that should be writable to the file. The ESTIMATED_SIZE characteristic is specified as "(ESTIMATED_SIZE => n)", where "n" is any NATURAL number.

The ATTRIBUTES parameter defines and provides initial values for attributes of the node. The ACCESS_CONTROL parameter specifies initial access control information to be established for the created node (see Section 4.4.2.1 for details).

The LEVEL parameter specifies the security level at which the file node is to be created.

The default value for the attribute FILE_KIND is SECONDARY_STORAGE. The default value may be overridden by explicitly specifying a value of QUEUE in the ATTRIBUTES parameter i.e., "(FILE_KIND => QUEUE)"). If the value of FILE_KIND is QUEUE, the default value of the attribute QUEUE_KIND is SOLO.

Parameters:

FILE — is a file handle, initially closed, to be opened.

BASE — is an open node handle to the node which will be the source of the primary relationship to the new node.

KEY — is the relationship key of the primary relationship to be created.

RELATION — is the relation name of the primary relationship to be created.

MODE — indicates the mode of the file.

FORM — indicates file characteristics.

ATTRIBUTES — defines initial values for attributes of the newly created node.

ACCESS_CONTROL — defines the initial access control information associated with the created node.

LEVEL — defines the classification label for the created node.

Exceptions:

NAME_ERROR — is raised if a node already exists for the node specified by KEY and RELATION or if KEY or RELATION is syntactically illegal or if any node identifying a group specified in the given ACCESS_CONTROL parameter is unobtainable.

USE_ERROR — is raised if any of the parameters ACCESS_CONTROL, LEVEL or ATTRIBUTES is syntactically or semantically illegal. USE_ERROR is also raised if interpretation of the ATTRIBUTES parameter would result in modification or creation of a predefined attribute other than FILE_KIND. USE_ERROR is also raised if RELATION is the name of a predefined relation which cannot be created by the user.

STATUS_ERROR
is raised if BASE is not an open node handle or if FILE is an open file handle prior to the call.

INTENT_VIOLATION
is raised if BASE was not opened with an intent establishing the right to append relationships.

SECURITY_VIOLATION
is raised if the operation represents a violation of mandatory access controls SECURITY_VIOLATION is raised only if the conditions for other exceptions are not present.

Additional Interface:

```
procedure CREATE(FILE:           in out FILE_TYPE;
                 NAME:           in     NAME_STRING;
                 MODE:           in     FILE_MODE := INOUT_FILE;
                 FORM:           in     LIST_TYPE := EMPTY_LIST;
                 ATTRIBUTES:     in     LIST_TYPE := EMPTY_LIST;
                 ACCESS_CONTROL: in     LIST_TYPE := EMPTY_LIST;
                 LEVEL:          in     LIST_TYPE := EMPTY_LIST)
is
    BASE : NODE_TYPE;
begin
    OPEN(BASE, BASE_PATH(NAME), (1=>APPEND_RELATIONSHIPS));
    CREATE(FILE, BASE, LAST_KEY(NAME), LAST_RELATION(NAME),
           MODE, FORM, ATTRIBUTES, ACCESS_CONTROL, LEVEL);
    CLOSE(BASE);
exception
    when others =>
        CLOSE(FILE);
        CLOSE(BASE);
    raise;
end CREATE;
```

5.3.4.3. Opening a text input or output file

```
procedure OPEN(FILE:  in out FILE_TYPE;
               NODE:  in     NODE_TYPE;
               MODE:  in     FILE_MODE);
```

Purpose:

This procedure opens a file handle on a file that has textual contents, given an open node handle on the file node.

Parameters:

FILE — is a file handle, initially closed, to be opened.

NODE — is an open node handle to the file node.

MODE — indicates the mode of the file.

Exceptions:

USE_ERROR is raised if the attribute ACCESS_METHOD of the file node does not have the value TEXT or the element type of the file does not correspond with the element type of this instantiation of the CAIS.TEXT_IO package. USE_ERROR is also raised if the node identified by NODE has a value of QUEUE for the attribute FILE_KIND and a value of MIMIC for the attribute QUEUE_KIND and the mimic queue file identified by FILE is being opened with MODE other than IN_FILE but the coupled file (see Section 5.3.5.13) has been deleted. USE_ERROR is also raised if the node identified by NODE has a value of TERMINAL or MAGNETIC_TAPE for the attribute FILE_KIND and the MODE is APPEND_FILE.

STATUS_ERROR
is raised if FILE is an open file handle at the time of the call on OPEN or if NODE is not an open node handle.

INTENT_VIOLATION
is raised if NODE has not been opened with an intent establishing the access rights required for the MODE, as specified in TABLE X.

Additional Interface:

```
procedure OPEN(FILE: in out FILE_TYPE;
               NAME: in     NAME_STRING;
               MODE: in     FILE_MODE)
is
    NODE : NODE_TYPE;
begin
    case MODE is
       when IN_FILE => OPEN(NODE, NAME,(1=>READ_CONTENTS));
       when OUT_FILE => OPEN(NODE, NAME,(1=>WRITE_CONTENTS));
       when INOUT_FILE =>OPEN(NODE,NAME,
                            (READ_CONTENTS,WRITE_CONTENTS));
       when APPEND_FILE => OPEN(NODE, NAME,(1=>APPEND_CONTENTS));
 end case;
    OPEN(FILE, NODE, MODE);
    CLOSE(NODE);
exception
    when others =>
        CLOSE(FILE);
        CLOSE(NODE);
    raise;
end OPEN;
```

Notes:

If the file identified by FILE is a mimic queue file which is being opened to read and its coupled file (see Section 5.3.5.13) has been deleted or has fewer elements than expected to be in the mimic queue file (e.g., if some of the contents of the coupled file have been deleted), read operations on the mimic queue file will encounter an end of file.

5.3.4.4. Deleting a text input or output file

```
procedure DELETE(FILE: in out FILE_TYPE);
```

Purpose:

In addition to the semantics specified in [LRM], the node associated with the open file handle FILE is made unobtainable as if a call to the DELETE_NODE procedure had been made.

Parameters:

FILE is an open file handle on the file being deleted.

Exceptions:

NAME_ERROR
is raised if the parent node of the node associated with the file identified by FILE is inaccessible.

USE_ERROR is raised if any primary relationships emanate from the node associated with the file identified by FILE.

STATUS_ERROR
is raised if FILE is not an open file handle.

LOCK_ERROR
is raised if access with intent WRITE_RELATIONSHIPS to the parent of the node to be deleted cannot be obtained due to an existing lock on the node.

ACCESS_VIOLATION
is raised if the current process does not have sufficient discretionary access control rights to obtain access to the parent of the node to be deleted with intent WRITE_RELATIONSHIPS or to obtain access to the node to be deleted with intent EXCLUSIVE_WRITE. ACCESS_VIOLATION is only raised if the conditions for NAME_ERROR are not present.

SECURITY_VIOLATION
is raised if the operation represents a violation of mandatory access controls. SECURITY_VIOLATION is raised only if the conditions for other exceptions are not present.

5.3.4.5. Resetting a text file

```
procedure RESET(FILE: inout FILE_TYPE;
                MODE: in    FILE_MODE);
```

Purpose:

In addition to the semantics specified in [LRM], application of this procedure to a file which represents a magnetic tape drive will cause the magnetic tape to be rewound to the filemark immediately preceding the current tape position. See Section 5.3.9 for more information on magnetic tapes.

Parameters:

FILE is an open file handle on the file begin reset.

MODE indicates the mode of the file.

Exceptions:

USE_ERROR is raised if the node associated with the file identified by FILE has a value of TERMINAL or MAGNETIC_TAPE for the attribute FILE_KIND and the MODE is APPEND_FILE.

5.3.4.6. Reading from a text file

procedure GET(...);

Purpose:

These procedures read characters from the specified text file.

For all values of the attribute FILE_KIND the CAIS defines only reading of the printable ASCII characters plus the format effectors called horizontal tabulation, vertical tabulation, carriage return, line feed, and form feed. All of the printable characters plus the horizontal tabulation and vertical tabulation characters may be read as characters. The characters carriage return and line feed are to be treated as line terminators whether encountered singly or together (i.e., CR, LF, CRLF, and LFCR are line terminators). The character form feed is to be treated as the page terminator.

When text is being read from a file whose file node attribute FILE_KIND has the value TERMINAL, it is expected that most implementations will provide facilities for editing the input entered by the user before making the characters available to a program for reading.

5.3.4.7. Writing to a text file

procedure PUT(...);

Purpose:

These procedures write characters to the specified file.

The CAIS supports the transfer of information to and from a single magnetic tape volume. Data transferred to and from magnetic tapes may consist of the following characters:

Characters	Representation of Characters
all printable characters	corresponding ASCII characters
horizontal tab	ASCII.HT
vertical tab	ASCII.VT
carriage return	ASCII.CR
line terminator	ASCII.LF
page terminator	ASCII.FF
file terminator	zero or more fill characters followed immediately by a tape mark.
fill character	ASCII.NUL

Use of other characters is not defined.

5.3.4.8. Setting the input file

procedure SET_INPUT(FILE : **in** FILE_TYPE);

Purpose:

In addition to the semantics specified in the [LRM], the file node associated with the file identified by FILE becomes the target of the relationship of the predefined relation CURRENT_INPUT of the current process node.

Parameters:

FILE is an open file handle.

Exceptions:

MODE_ERROR
is raised if the mode of the fi identified by FILE is OUT_FILE or APPEND_FILE.

STATUS_ERROR
is raised if FILE is not an open file handle.

LOCK_ERROR
is raised if the current process node is LOCKed against writing relationships.

5.3.4.9. Setting the output file

procedure SET_OUTPUT(FILE : **in** FILE_TYPE);

Purpose:

In addition to the semantics specified in the [LRM], the file node associated with FILE becomes the target of the relationship of the predefined relation CURRENT_OUTPUT of the current process node.

Parameters:

FILE is an open file handle.

Exceptions:

MODE_ERROR
is raised if the mode of the file identified by FILE is IN_FILE.

STATUS_ERROR
is raised if FILE is not an open file handle.

LOCK_ERROR
is raised if the current process node is LOCKed against writing relationships.

5.3.4.10. Setting the error file

procedure SET_ERROR(FILE : **in** FILE_TYPE);

Purpose:

The file node associated with the file identified by FILE becomes the target of the relationship of the predefined relation CURRENT_ERROR of the current process node.

Parameters:

FILE is an open file handle.

Exceptions:

MODE_ERROR
is raised if the mode of the file identified by FILE is IN_FILE.

STATUS_ERROR
is raised if FILE is not an open file handle.

LOCK_ERROR
is raised if the current process node is LOCKed against writing relationships.

5.3.4.11. Determining the standard error file

function STANDARD_ERROR **return** FILE_TYPE;

Purpose:

This function returns an open file handle to the target node of the relationship of the predefined relation STANDARD_ERROR that was set at the start of program execution.

Parameters:

None.

Exceptions:

LOCK_ERROR
is raised if the current process node is locked against reading relationships.

5.3.4.12. Determining the current error file

function CURRENT_ERROR **return** FILE_TYPE;

Purpose:

This function returns an open file handle to the target node of the relationship of the predefined relation CURRENT_ERROR which is either the standard error file or the file specified in the most recent invocation of SET_ERROR in the current process.

Parameters:

None.

Exceptions:

LOCK_ERROR
is raised if the current process node is locked against reading relationships.

5.3.5. Package IO_CONTROL

This package defines facilities that may be used to modify or query the functionality of CAIS files. It provides for association of input and output text files with an output logging file. It also provides facilities for forcing data from an internal file to its associated external file, for manipulation of function keys and prompt strings and for creating mimic and copy queues.

5.3.5.1. Obtaining an open node handle from a file handle

```
procedure OPEN_FILE_NODE(FILE:       in      FILE_TYPE;
                         NODE:       in out  NODE_TYPE;
                         INTENT:     in      INTENTION;
                         TIME_LIMIT: in      DURATION:=NO_DELAY);
```

Purpose:

This procedure returns an open node handle for the node associated with the file identified by FILE.

Parameters:

FILE — is an open file handle.

NODE — is a node handle, initially closed, to be opened.

INTENT — is the intent of subsequent operations on the node; the actual parameter takes the form of an array aggregate.

TIME_LIMIT — specifies a time limit for the delay on waiting for the unlocking of a node in accordance with the desired INTENT.

Exceptions:

NAME_ERROR
is raised if the node to which a handle is to be opened is inaccessible or if it is unobtainable and the given INTENT includes any intent other than EXISTENCE.

USE_ERROR is raised if the specified INTENT is an empty array.

STATUS_ERROR
is raised if FILE is not an open file handle or if NODE is an open node handle.

LOCK_ERROR
is raised if the OPEN_FILE_NODE operation is delayed beyond the specified time limit due to the existence of locks in conflict with the specified intent.

ACCESS_VIOLATION
is raised if the current process' discretionary access control rights are insufficient to obtain access to the node consistent with the specified INTENT. ACCESS_VIOLATION is raised only if the conditions for NAME_ERROR are not present.

SECURITY_VIOLATION
is raised if the operation represents a violation of mandatory access controls. SECURITY_VIOLATION is raised only if the conditions for other exceptions are not present.

5.3.5.2. Synchronizing program files with system files

```
procedure SYNCHRONIZE(FILE :in FILE_TYPE);
```

Purpose:

This procedure forces all data that has been written to the internal file identified by FILE to be transmitted to the external file with which it is associated.

Parameters:

FILE is an open file handle on the internal file to be synchronized.

Exceptions:

USE_ERROR is raised if the file identified by FILE is of mode IN_FILE.

STATUS_ERROR
is raised if FILE is not an open file handle.

5.3.5.3. Establishing a log file

```
procedure SET_LOG(FILE     :in FILE_TYPE;
                  LOG_FILE :in FILE_TYPE);
```

Purpose:

This procedure associates a log file identified by LOG_FILE with the file identified by FILE. All elements written to the internal file identified by FILE are also written to the file identified by LOG_FILE.

Parameters:

FILE is an open file handle on the file which is to have a log file.

LOG_FILE is an open file handle on the file to which the log should be written.

Exceptions:

MODE_ERROR
is raised if the mode of either of the files identified by FILE or LOG_FILE is IN_FILE.

USE_ERROR is raised if the nodes associated with the files identified by FILE and LOG_FILE do not have the same values for the attribute ACCESS_METHOD or if the files do not have compatible elements (implementation-defined).

STATUS_ERROR
is raised if FILE and LOG_FILE are not both open file handles.

5.3.5.4. Removing a log file

```
procedure CLEAR_LOG(FILE :in FILE_TYPE);
```

Purpose:

This procedure removes the association established between the file identified by FILE and its log file.

Parameters:

FILE is an open file handle on a file that has a log file.

Exceptions:

STATUS_ERROR
is raised if FILE is not an open file handle.

Notes:

If FILE is an open file handle and there is no log file, this procedure has no effect.

5.3.5.5. Determining whether logging is specified

```
function LOGGING (FILE :in FILE_TYPE)
        return BOOLEAN;
```

Purpose:

This function returns TRUE if the file identified by FILE has a log file associated with it; otherwise, it returns FALSE.

Parameters:

FILE is an open file handle.

Exceptions:

STATUS_ERROR
is raised if FILE is not an open file handle.

5.3.5.6. Determining the log file

```
function GET_LOG (FILE :in FILE_TYPE)
        return FILE_TYPE;
```

Purpose:

This function returns an open file handle on the log file currently associated with the file identified by FILE.

Parameters:

FILE is an open file handle.

Exceptions:

USE_ERROR is raised if the file identified by FILE has no log file.

STATUS_ERROR
is raised if FILE is not an open file handle.

5.3.5.7. Determining the file size

```
function NUMBER_OF_ELEMENTS (FILE :in FILE_TYPE)
         return NATURAL;
```

Purpose:

This function returns the number of data elements contained in the file identified by FILE. The package that was used to write the elements determines what constitutes a data element.

Parameters:

FILE is an open file handle on a secondary storage or queue file.

Exceptions:

USE_ERROR is raised if the value of the attribute FILE_KIND of the node associated with the file identified by FILE is TERMINAL or MAGNETIC_TAPE.

STATUS_ERROR
is raised if FILE is not an open file handle.

5.3.5.8. Setting the prompt string

```
procedure SET_PROMPT(TERMINAL :in FILE_TYPE;
                     PROMPT   :in STRING);
```

Purpose:

This procedure sets the prompt string for the output terminal file associated with the input terminal file identified by TERMINAL. All future requests for a line of input from the input terminal file identified by TERMINAL will first output the prompt string to the associated output terminal file.

Parameters:

TERMINAL is an open file handle identifying an input terminal file.

PROMPT is the new value of the prompt string.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the attribute FILE_KIND or if SCROLL or PAGE is not a value of the attribute TERMINAL_KIND of the node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is not of mode IN_FILE or INOUT_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

5.3.5.9. Determining the prompt string

```
function GET_PROMPT (TERMINAL :in FILE_TYPE)
        return STRING;
```

Purpose:

This function returns the current prompt string for the input terminal file identified by TERMINAL.

Parameters:

TERMINAL is an open file handle identifying an input terminal file.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the attribute FILE_KIND or if SCROLL or PAGE is not a value of the attribute TERMINAL_KIND of the node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is not of mode IN_FILE or INOUT_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

5.3.5.10. Determining intercepted characters

```
function INTERCEPTED_CHARACTERS (TERMINAL :in FILE_TYPE)
        return CHARACTER_ARRAY;
```

Purpose:

This function returns the array CHARACTER_ARRAY that indicates the characters that can never appear in the input terminal file identified by TERMINAL due to characteristics of the underlying system and the individual physical terminal. A value of TRUE indicates that the character can appear; a value of FALSE indicates that it cannot appear.

Parameters:

TERMINAL is an open file handle on an input terminal file.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the attribute FILE_KIND of the node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is not of mode IN_FILE or INOUT_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

5.3.5.11. Enabling and disabling function key usage

```
procedure ENABLE_FUNCTION_KEYS (TERMINAL :in FILE_TYPE;
                                ENABLE   :in BOOLEAN);
```

Purpose:

This procedure establishes whether data read as the result of pressing a function key on the physical input terminal is to appear in the input terminal file as ASCII character sequences or as function key identification numbers. A value of TRUE for ENABLE indicates that the function keys should appear as numbered values. A value of FALSE indicates that the function keys should appear as ASCII character sequences. The function keys are said to have been enabled if the value of ENABLE is TRUE.

Parameters:

TERMINAL is an open file handle on an input terminal file.

ENABLE indicates how function keys are to appear.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the attribute FILE_KIND of the node associated with the file identified by the parameter TERMINAL. USE_ERROR is also raised if the file identified by TERMINAL is of mode OUT_FILE or APPEND_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

Notes:

This procedure has no effect on read operations of the CAIS.TEXT_IO package.

5.3.5.12. Determining function key usage

```
function FUNCTION_KEYS_ENABLED (TERMINAL :in FILE_TYPE)
    return BOOLEAN;
```

Purpose:

This function returns TRUE if the function keys are enabled, i.e., they appear in the input terminal file as numbered values; otherwise it returns FALSE.

Parameters:

TERMINAL is an open file handle on an input terminal file.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the attribute FILE_KIND of the node associated with the file identified by the parameter TERMINAL. USE_ERROR is also raised if the file identified by TERMINAL is of mode OUT_FILE or APPEND_FILE.

```
    CLOSE(BASE);
exception
    when others =>
        CLOSE(BASE);
    raise;
end COUPLE;

procedure COUPLE(QUEUE_BASE:      in NODE_TYPE;
                 QUEUE_KEY:       in RELATIONSHIP_KEY :=
                                         LATEST_KEY;
                 QUEUE_RELATION:  in RELATION_NAME :=
                                         DEFAULT_RELATION;
                 FILE_NAME:       in NAME_STRING;
                 FORM:            in LIST_TYPE := EMPTY_LIST;
                 ATTRIBUTES:      in LIST_TYPE;
                 ACCESS_CONTROL:  in LIST_TYPE := EMPTY_LIST;
                 LEVEL:           in LIST_TYPE := EMPTY_LIST)
is
    FILE_NODE : NODE_TYPE;
begin
    OPEN(FILE_NODE, FILE_NAME
                (READ_ATTRIBUTES, READ_CONTENTS));
    COUPLE(QUEUE_BASE, QUEUE_KEY, QUEUE_RELATION,
            FILE_NODE, FORM, ATTRIBUTES, ACCESS_CONTROL, LEVEL);
    CLOSE(FILE_NODE);
exception
    when others =>
        CLOSE(FILE_NODE);
    raise;
end COUPLE;

procedure COUPLE(QUEUE_NAME:      in NAME_STRING;
                 FILE_NAME:       in NAME_STRING;
                 FORM:            in LIST_TYPE := EMPTY_LIST;
                 ATTRIBUTES:      in LIST_TYPE;
                 ACCESS_CONTROL:  in LIST_TYPE := EMPTY_LIST;
                 LEVEL:           in LIST_TYPE := EMPTY_LIST)
is
    FILE_NODE : NODE_TYPE;
    QUEUE_BASE : NODE_TYPE;
begin
    OPEN(QUEUE_BASE, BASE_PATH(QUEUE_NAME),
                        (1=>APPEND_RELATIONSHIPS));
    OPEN(FILE_NODE, FILE_NAME,
                (READ_ATTRIBUTES, READ_CONTENTS));
    COUPLE(QUEUE_BASE, LAST_KEY(QUEUE_NAME),
                        LAST_RELATION(QUEUE_NAME),
            FILE_NODE, FORM, ATTRIBUTES, ACCESS_CONTROL, LEVEL);
    CLOSE(QUEUE_BASE);
    CLOSE(FILE_NODE);
exception
    when others =>
        CLOSE(QUEUE_BASE);
        CLOSE(FILE_NODE);
    raise;
end COUPLE;
```

Notes:

Read operations on a mimic queue file whose coupled file has been deleted or has fewer elements than expected in the mimic queue file (e.g., if some of the contents of the coupled file have been deleted) will encounter an end of file. Attempts to opena mimic queue file whose coupled file has been deleted with MODE other than IN_FILE raises a USE_ERROR exception. Attempts

to open with MODE other than IN-FILE a mimic queue file whose coupled file has been deleted will raise a USE_ERROR exception.

5.3.6. Package SCROLL_TERMINAL

This package provides the functionality of a scroll terminal. A scroll terminal consists of two devices: an input device (keyboard) and an associated output device (a printer or display). A scroll terminal may be accessed either as a single file of mode INOUT_FILE or as two files: one of mode IN_FILE (the keyboard) and the other of mode OUT_FILE (the printer or display). As keys are pressed on the scroll terminal keyboard, the transmitted characters are made available for reading by the CAIS.SCROLL_TERMINAL package. As characters are written to the scroll terminal file, they are displayed on the output device.

The output devices for scroll terminals have *positions* in which printable ASCII characters may be graphically displayed. The positions are arranged into horizontal rows and vertical columns. Each position is identifiable by the combination of a positive row number and a positive column number. An output device for a scroll terminal has a fixed number of columns and might have a fixed number of rows. The rows are incrementally indexed starting with one after performing the NEW_PAGE (see Section 5.3.6.19) operation. The columns are incrementally indexed starting with one at the left side of the output device.

The *active position* on the output device of a scroll terminal is the position at which the next operation will be performed. The active position is said to *advance* if (1) the row number of the new position is greater than the row number of the old position or (2) the row number of the new position is the same as the row number of the old position and the new position has a greater column number. Similarly, a position is said to *precede* the active position if (1) the row number of the position is less than the row number of the active position or (2) the row number of the position is the same as the row number of the active position and the column number of the position is smaller than the column number of the active position.

5.3.6.1. Subtypes

```
subtype FILE_TYPE is CAIS.IO_DEFINITIONS.FILE_TYPE;

subtype FUNCTION_KEY_DESCRIPTOR is
        CAIS.IO_DEFINITIONS.FUNCTION_KEY_DESCRIPTOR;

subtype POSITION_TYPE is CAIS.IO_DEFINITIONS.POSITION_TYPE;

subtype TAB_ENUMERATION is CAIS.IO_DEFINITIONS.TAB_ENUMERATION;
```

FILE_TYPE describes the type for file handles. FUNCTION_KEY_DESCRIPTOR is used to obtain information about function keys read from a terminal. POSITION-TYPE describes the type of a position on a terminal. TAB_ENUMERATION is used to specify the kind of tab stop to be set.

5.3.6.2. Setting the active position

```
procedure SET_POSITION(TERMINAL: in FILE_TYPE;
                       POSITION: in POSITION_TYPE);
```

Purpose:

This procedure advances the active position to the specified POSITION in the output terminal file identified by TERMINAL.

Parameters:

TERMINAL is an open file handle on an output terminal file.

POSITION is the new active position in the output terminal file.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND, or SCROLL is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode IN_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

LAYOUT_ERROR
is raised if the position does not exist on the terminal or the position precedes the active position.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
procedure SET_POSITION (POSITION: in POSITION_TYPE)
is
begin
   SET_POSITION(CURRENT_OUTPUT, POSITION);
end SET_POSITION;
```

5.3.6.3. Determining the active position

```
function GET_POSITION(TERMINAL: in FILE_TYPE)
         return POSITION_TYPE;
```

Purpose:

This function returns the active position of the output terminal file identified by TERMINAL.

Parameters:

TERMINAL is an open file handle on an output terminal file.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or SCROLL is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode IN_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
function GET_POSITION
        return POSITION_TYPE
is
begin
    return GET_POSITION(CURRENT_OUTPUT);
end GET_POSITION;
```

5.3.6.4. Determining the size of the terminal

```
function TERMINAL_SIZE(TERMINAL: in FILE_TYPE)
        return POSITION_TYPE;
```

Purpose:

This function returns the maximum row and maximum column of the output terminal file identified by TERMINAL. A value of zero for the row number indicates that the row number is unlimited.

Parameters:

TERMINAL is an open file handle on an output terminal file.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or SCROLL is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode IN_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
function TERMINAL_SIZE
        return POSITION_TYPE
is
begin
```

```
    return TERMINAL_SIZE(CURRENT_OUTPUT);
end TERMINAL_SIZE;
```

5.3.6.5. Setting a tab stop

```
procedure SET_TAB(TERMINAL:  in FILE_TYPE;
                  KIND:      in TAB_ENUMERATION := HORIZONTAL);
```

Purpose:

This procedure establishes a horizontal tab stop at the column of the active position if KIND is HORIZONTAL, or a vertical tab stop at the row of the active position if KIND is VERTICAL.

Parameters:

TERMINAL is an open file handle on an output terminal file.

KIND is the kind (horizontal or vertical) of tab stop to be set.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or SCROLL is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL. USE_ERROR is also raised if the number of rows for the terminal is unlimited and KIND is VERTICAL.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode IN_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
procedure SET_TAB (KIND: in TAB_ENUMERATION := HORIZONTAL)
is
begin
    SET_TAB(CURRENT_OUTPUT, KIND);
end SET_TAB;
```

5.3.6.6. Clearing a tab stop

```
procedure CLEAR_TAB(TERMINAL:  in FILE_TYPE;
                    KIND:      in TAB_ENUMERATION := HORIZONTAL);
```

Purpose:

This procedure removes a horizontal tab stop from the column of the active position if KIND is HORIZONTAL or a vertical tab stop from the row of the active position if KIND is VERTICAL.

Parameters:

TERMINAL is an open file handle on an output terminal file.

KIND is the kind (horizontal or vertical) of tab stop to be removed.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or SCROLL is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL, or if there is no tab stop of the designated kind at the active position.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode IN_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
procedure CLEAR_TAB(KIND: in TAB_ENUMERATION := HORIZONTAL)
is
begin
    CLEAR_TAB(CURRENT_OUTPUT, KIND);
end CLEAR_TAB;
```

5.3.6.7. Advancing to the next tab position

```
procedure TAB(TERMINAL: in FILE_TYPE;
              KIND:     in TAB_ENUMERATION := HORIZONTAL;
              COUNT:    in POSITIVE := 1);
```

Purpose:

This procedure advances the active position COUNT tab stops. Horizontal advancement causes a change in only the column number of the active position. Vertical advancement causes a change in only the row number of the active position.

Parameters:

TERMINAL is an open file handle on an output terminal file.

KIND is the kind (horizontal or vertical) of tab to be advanced.

COUNT is a positive integer indicating the number of tab stops the active position is to advance.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND, SCROLL is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL, or there are fewer than COUNT tab stops of the designated kind after the active position.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode IN_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
procedure TAB(KIND:  in TAB_ENUMERATION := HORIZONTAL;
              COUNT: in POSITIVE := 1)
is
begin
   TAB(CURRENT_OUTPUT, KIND, COUNT);
end TAB;
```

5.3.6.8. Sounding a terminal bell

```
procedure BELL(TERMINAL: in FILE_TYPE);
```

Purpose:

This procedure sounds the bell (beeper) on the terminal represented by the output terminal file identified by TERMINAL.

Parameters:

TERMINAL is an open file handle on an output terminal file.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or SCROLL is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode IN_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
procedure BELL
is
begin
   BELL(CURRENT_OUTPUT);
end BELL;
```

5.3.6.9. Writing to the terminal

```
procedure PUT(TERMINAL: in FILE_TYPE;
              ITEM:     in CHARACTER);
```

Purpose:

This procedure writes a single character to the output terminal file identified by TERMINAL and advances the active position by one column.

Parameter:

TERMINAL is an open file handle on an output terminal file.

ITEM is the character to be written.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or SCROLL is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode IN_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interfaces:

```
procedure PUT(ITEM: in CHARACTER)
is
begin
   PUT(CURRENT_OUTPUT, ITEM);
end PUT;

procedure PUT(TERMINAL: in FILE_TYPE;
              ITEM:     in STRING)
is
begin
   for INDEX in ITEM'FIRST .. ITEM'LAST loop
      PUT(TERMINAL, ITEM(INDEX));
   end loop;
end PUT;

procedure PUT(ITEM: in STRING)
is
```

```
begin
    PUT(CURRENT_OUTPUT, ITEM);
end PUT;
```

Notes:

After a character is written in the rightmost position of a row, the active position is the first position of the next row.

5.3.6.10. Enabling echo on a terminal

```
procedure SET_ECHO(TERMINAL: in FILE_TYPE;
                   TO:       in BOOLEAN := TRUE);
```

Purpose:

This procedure establishes whether characters which appear in the input terminal file identified by TERMINAL are echoed to its associated output terminal file. When TO is TRUE, each character is echoed to the output terminal file. When TO is FALSE, each character which appears in the input terminal file is not echoed to its associated output terminal file.

Parameters:

TERMINAL is an open file handle on an input terminal file.

TO indicates whether or not to echo input characters.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or SCROLL is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode OUT_FILE or APPEND_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
procedure SET_ECHO(TO: in BOOLEAN := TRUE)
is
begin
    SET_ECHO(CURRENT_INPUT, TO);
end SET_ECHO;
```

5.3.6.11. Querying echo on a terminal

```
function ECHO(TERMINAL: in FILE_TYPE)
        return BOOLEAN;
```

Purpose:

This function returns TRUE if echo is enabled; otherwise it returns FALSE.

Parameters:

TERMINAL is an open file handle on an input terminal file.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or SCROLL is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode OUT_FILE or APPEND_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
function ECHO return BOOLEAN
is
begin
   return ECHO(CURRENT_INPUT);
end ECHO;
```

5.3.6.12. Determining the number of function keys

```
function MAXIMUM_FUNCTION_KEY(TERMINAL: in FILE_TYPE)
        return NATURAL;
```

Purpose:

This function returns the maximum function key identification number that can be returned by a GET operation on the input terminal file identified by TERMINAL.

Parameters:

TERMINAL is an open file handle on an input terminal file.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or

SCROLL is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
: is raised if the file identified by TERMINAL is of mode OUT_FILE or APPEND_FILE.

STATUS_ERROR
: is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
: is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
function MAXIMUM_FUNCTION_KEY return NATURAL
is
begin
    return MAXIMUM_FUNCTION_KEY(CURRENT_INPUT);
end MAXIMUM_FUNCTION_KEY;
```

5.3.6.13. Reading a character from a terminal

```
procedure GET(TERMINAL: in      FILE_TYPE;
              ITEM:         out CHARACTER;
              KEYS:         out FUNCTION_KEY_DESCRIPTOR);
```

Purpose:

This procedure reads either a single character into ITEM or a single function key identification number into KEYS from the input terminal file identified by TERMINAL.

Parameters:

TERMINAL is an open file handle on an input terminal file.

ITEM is the character that was read.

KEYS is the description of the function key identification number that was read.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or SCROLL is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
: is raised if the file identified by TERMINAL is of mode OUT_FILE or APPEND_FILE.

STATUS_ERROR
: is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
procedure GET(ITEM:    out CHARACTER;
              KEYS:    out FUNCTION_KEY_DESCRIPTOR)
is
begin
  GET(CURRENT_INPUT, ITEM, KEYS);
end GET;
```

Notes:

This procedure will only return function key identification numbers in KEYS if function keys have been enabled (see Section 5.3.5.11). Otherwise the characters in the ASCII character sequence representing the function key will appear one at a time in ITEM.

5.3.6.14. Reading all available characters from a terminal

```
procedure GET(TERMINAL: in    FILE_TYPE;
              ITEM:     out STRING;
              LAST:     out NATURAL;
              KEYS:     out FUNCTION_KEY_DESCRIPTOR);
```

Purpose:

This procedure successively reads characters and function key identification numbers into ITEM and KEYS respectively, until either all positions of ITEM or KEYS are filled or there are no more characters available in the input terminal file. Upon completion, LAST contains the index of the last position in ITEM to contain a character that has been read.

Parameters:

TERMINAL is an open file handle on an input terminal file.

ITEM is the string of characters that were read.

LAST is the position of the last character read in ITEM.

KEYS is a description of the function key identification numbers that were read.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or SCROLL is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode OUT_FILE or APPEND_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
procedure GET(ITEM: out STRING;
              LAST: out NATURAL;
              KEYS: out FUNCTION_KEY_DESCRIPTOR)
is
begin
    GET(CURRENT_INPUT, ITEM, LAST, KEYS);
end GET;
```

Notes:

This procedure will only return function key identification numbers in KEYS if function keys have been enabled (see Section 5.3.5.11). Otherwise the characters in the ASCII character sequence representing the function key will appear in ITEM. If there are no elements available for reading from the input terminal file, then LAST has a value one less than ITEM'FIRST and FUNCTION_KEY_COUNT(KEYS) (see Section 5.3.6.15) is equal to zero.

5.3.6.15. Determining the number of function keys that were read

```
function FUNCTION_KEY_COUNT(KEYS: in FUNCTION_KEY_DESCRIPTOR)
        return NATURAL;
```

Purpose:

This function returns the number of function keys described in KEYS.

Parameters:

KEYS is the function key descriptor being queried.

Exceptions:

None

5.3.6.16. Determining function key usage

```
procedure FUNCTION_KEY(KEYS:            in FUNCTION_KEY_DESCRIPTOR;
                       INDEX:           in POSITIVE;
                       KEY_IDENTIFIER:     out POSITIVE;
                       POSITION:           out NATURAL);
```

Purpose:

This procedure returns the identification number of a function key and the position in the string (read at the same time as the function keys) of the character following the function key.

Parameters:

KEYS is the description of the function key identification numbers that were read.

INDEX is the index in KEYS of the function key to be queried.

KEY_IDENTIFIER
is the identification number of a function key.

POSITION is the position of the character read after the function key.

Exceptions:

CONSTRAINT_ERROR
is raised if INDEX is greater than FUNCTION_KEY_COUNT(KEYS).

5.3.6.17. Determining the name of a function key

```
procedure FUNCTION_KEY_NAME(TERMINAL:       in     FILE_TYPE;
                            KEY_IDENTIFIER: in     POSITIVE;
                            KEY_NAME:          out STRING;
                            LAST:              out POSITIVE);
```

Purpose:

This function returns (in KEY_NAME) the string identification of the function key sequence designated by KEY_IDENTIFIER. It also returns the index of the last character of the function key name in LAST.

Parameters:

TERMINAL is an open file handle on an input terminal file.

KEY_IDENTIFIER
is the identification number of a function key.

KEY_NAME is the name of the key designated by KEY_IDENTIFIER.

LAST is the position in KEY_NAME of the last character of the function key name.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or SCROLL is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode OUT_FILE or APPEND_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

CONSTRAINT_ERROR
is raised if the value of KEY_IDENTIFIER is greater than

MAXIMUM_FUNCTION_KEY(TERMINAL) or the string identification of the function key sequence is longer than the string KEY_NAME.

Additional Interface:

```
procedure FUNCTION_KEY_NAME
   (KEY_IDENTIFIER: in      POSITIVE;
    KEY_NAME:           out STRING;
    LAST:               out POSITIVE)
is
begin
    FUNCTION_KEY_NAME(CURRENT_INPUT,
                  KEY_IDENTIFIER, KEY_NAME, LAST);
end FUNCTION_KEY_NAME;
```

5.3.6.18. Advancing the active position to the next line

```
procedure NEW_LINE(TERMINAL: in FILE_TYPE;
                   COUNT:    in POSITIVE := 1);
```

Purpose:

This procedure advances the active position in the output terminal file to column one, COUNT lines after the active position.

Parameters:

TERMINAL is an open file handle on an output terminal file.

COUNT is the number of lines to advance.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or SCROLL is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode IN_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
procedure NEW_LINE(COUNT:in POSITIVE := 1)
is
begin
    NEW_LINE(CURRENT_OUTPUT, COUNT);
end NEW_LINE;
```

5.3.6.19. Advancing the active position to the next page

```
procedure NEW_PAGE(TERMINAL: in FILE_TYPE);
```

Purpose:

This procedure advances the active position in the output terminal file to the first column of the first line of a new page.

Parameters:

TERMINAL is an open file handle on an output terminal file.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or SCROLL is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode IN_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
procedure NEW_PAGE
is
begin
    NEW_PAGE(CURRENT_OUTPUT);
end NEW_PAGE;
```

5.3.7. Package PAGE_TERMINAL

This package provides the functionality of a page terminal. A page terminal consists of two devices: an input device (keyboard) and an associated output device (display). A page terminal may be accessed either as a single file of mode INOUT_FILE or as two files: one of mode IN_FILE (the keyboard) and the other of mode OUT_FILE (the display). As keys are pressed on the page terminal keyboard, the transmitted characters are made available for reading by the CAIS.PAGE_TERMINAL package. As characters are written to the page terminal file, they are displayed on the output device.

The display for a page terminal has positions in which printable ASCII characters may be graphically displayed. The positions are arranged into horizontal rows and vertical columns. Each position is identifiable by the combination of a row number and a column number. A display has a fixed number of rows and columns. The rows and columns of a display are identified by positive numbers. The rows are incrementally indexed starting with one at the top of the display. The columns are incrementally indexed starting with one at the left side of the display.

The active position on the display of a page terminal is the position at which the next operation will be performed. The active position is said to advance if (1) the row number of the new position is greater than the row number of the old position or (2) the row number of the new position is the same as the row number of the old position and the new position has a greater column number. Similarly, a position is said to *precede* the active position if (1) the row number of the position is less than the row number of the active position or (2) the row number of the position is the same as the row number of the active position and the column number of the position is smaller than the column number of the active position.

5.3.7.1. Types, subtypes and constants

```
subtype FILE_TYPE is CAIS.IO_DEFINITIONS.FILE_TYPE;

subtype FUNCTION_KEY_DESCRIPTOR is
    CAIS.IO_DEFINITIONS.FUNCTION_KEY_DESCRIPTOR;

subtype POSITION_TYPE is CAIS.IO_DEFINITIONS.POSITION_TYPE;

subtype TAB_ENUMERATION is CAIS.IO_DEFINITIONS.TAB_ENUMERATION;

type SELECT_ENUMERATION is
   (FROM_ACTIVE_POSITION_TO_END,
    FROM_START_TO_ACTIVE_POSITION,
    ALL_POSITIONS);

type GRAPHIC_RENDITION_ENUMERATION is
   (PRIMARY_RENDITION,
    BOLD,
    FAINT,
    UNDERSCORE,
    SLOW_BLINK,
    RAPID_BLINK,
    REVERSE_IMAGE);

type GRAPHIC_RENDITION_ARRAY is array(GRAPHIC_RENDITION_ENUMERATION)
    of BOOLEAN;

DEFAULT_GRAPHIC_RENDITION : constant GRAPHIC_RENDITION_ARRAY
    := (PRIMARY_RENDITION => TRUE, BOLD..REVERSE_IMAGE => FALSE);
```

FILE_TYPE describes the type for file handles. FUNCTION_KEY_DESCRIPTOR is used to obtain information about function keys read from a terminal. POSITION_TYPE describes the type of a position on a terminal. TAB_ENUMERATION is used to specify the kind of tab stop to be set. SELECT_ENUMERATION is used in ERASE_IN_DISPLAY and ERASE_IN_LINE to determine the portion of the display or line to be erased. GRAPHIC_RENDITION_ENUMERATION, GRAPHIC_RENDITION_ARRAY, and DEFAULT_GRAPHIC_RENDITION are used to determine display characteristics of printable characters.

5.3.7.2. Setting the active position

```
procedure SET_POSITION(TERMINAL : in FILE_TYPE;
                       POSITION : in POSITION_TYPE);
```

Purpose:

This procedure advances the active position to the specified POSITION on the output terminal file identified by TERMINAL.

Parameters:

TERMINAL is an open file handle on an output terminal file.

POSITION is the new active position in the output terminal file.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or PAGE is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode IN_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

LAYOUT_ERROR
is raised if the position does not exist on the terminal.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
procedure SET_POSITION(POSITION :  in POSITION_TYPE)
is
begin
    SET_POSITION(CURRENT_OUTPUT, POSITION);
end SET_POSITION;
```

5.3.7.3. Determining the active position

```
function GET_POSITION(TERMINAL : in FILE_TYPE)
        return POSITION_TYPE;
```

Purpose:

This function returns the active position of the output terminal file identified by TERMINAL.

Parameters:

TERMINAL is an open file handle on an output terminal file.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or PAGE is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode IN_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
function GET_POSITION return POSITION_TYPE
is
begin
   return GET_POSITION(CURRENT_OUTPUT);
end GET_POSITION;
```

5.3.7.4. Determining the size of the terminal

```
function TERMINAL_SIZE(TERMINAL : in FILE_TYPE)
        return POSITION_TYPE;
```

Purpose:

This function returns the maximum row and maximum column of the output terminal file identified by TERMINAL.

Parameters:

TERMINAL is an open file handle on a terminal file.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or PAGE is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode IN_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
function TERMINAL_SIZE
        return POSITION_TYPE
is
begin
   return TERMINAL_SIZE(CURRENT_OUTPUT);
end TERMINAL_SIZE;
```

5.3.7.5. Setting a tab stop

```
procedure SET_TAB(TERMINAL : in FILE_TYPE;
                  KIND     : in TAB_ENUMERATION := HORIZONTAL);
```

Purpose:

This procedure establishes a horizontal tab stop at the column of the active position if KIND is HORIZONTAL, or a vertical tab stop at the row of the active position if KIND is VERTICAL.

Parameters:

TERMINAL is an open file handle on a terminal file.

KIND is the kind (horizontal or vertical) of tab to be set.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or PAGE is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode IN_FILE.

STATUS_ERROR
is raised if the file identified by TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
procedure SET_TAB(KIND : in TAB_ENUMERATION := HORIZONTAL)
is
begin
   SET_TAB(CURRENT_OUTPUT, KIND);
end SET_TAB;
```

5.3.7.6. Clearing a tab stop

```
procedure CLEAR_TAB(TERMINAL : in FILE_TYPE;
                    KIND     : in TAB_ENUMERATION := HORIZONTAL);
```

Purpose:

This procedure removes a horizontal tab stop from the column of the active position if KIND is HORIZONTAL or a VERTICAL tab stop from the row of the active position if KIND is VERTICAL.

Parameters:

TERMINAL is an open file handle on a terminal file.

KIND is the kind (horizontal or vertical) of tab stop to be removed.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or PAGE is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL, or if there is no tab stops of the designated kind at the active position.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode IN_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
procedure CLEAR_TAB(KIND : in TAB_ENUMERATION := HORIZONTAL)
is
begin
   CLEAR_TAB(CURRENT_OUTPUT, KIND);
end CLEAR_TAB;
```

5.3.7.7. Advancing to the next tab position

```
procedure TAB(TERMINAL : in FILE_TYPE;
              KIND     : in TAB_ENUMERATION := HORIZONTAL;
              COUNT    : in POSITIVE := 1);
```

Purpose:

This procedure advances the active position COUNT tab stops. Horizontal advancement causes a change in only the column number of the active position. Vertical advancement causes a change in only the row number of the active position.

Parameters:

TERMINAL is an open file handle on an output terminal file.

KIND is the kind (horizontal or vertical) of tab stop to be advanced.

COUNT is a positive integer indicating the number of tab stops the active position is to advance.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or PAGE is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL, or there are fewer than COUNT tab stops of the designated kind after the active position.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode IN_FILE.

STATUS_ERROR
is raised if the file identified by TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
procedure TAB(KIND  : in TAB_ENUMERATION := HORIZONTAL;
              COUNT : in POSITIVE := 1);
is
begin
    TAB(CURRENT_OUTPUT, KIND, COUNT);
end TAB;
```

5.3.7.8. Sounding a terminal bell

```
procedure BELL(TERMINAL : in FILE_TYPE);
```

Purpose:

This procedure sounds the bell (beeper) on the terminal represented by the output terminal file identified by TERMINAL.

Parameters:

TERMINAL is an open file handle on an output terminal file.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or PAGE is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode IN_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
procedure BELL
is
begin
    BELL(CURRENT_OUTPUT);
```

```
end BELL;
```

5.3.7.9. Writing to the terminal

```
procedure PUT(TERMINAL : in FILE_TYPE;
              ITEM     : in CHARACTER);
```

Purpose:

This procedure writes a single character to the output terminal file identified by TERMINAL and advances the active position by one column.

Parameter:

TERMINAL is an open file handle on an output terminal file.

ITEM is the character to be written.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or PAGE is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode IN_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interfaces:

```
procedure PUT(ITEM : in CHARACTER)
is
begin
   PUT(CURRENT_OUTPUT, ITEM);
end PUT;

procedure PUT(TERMINAL : in FILE_TYPE;
              ITEM     : in STRING)
is
begin
   for INDEX in ITEM'FIRST .. ITEM'LAST loop
      PUT(TERMINAL, ITEM(INDEX));
   end loop;
end PUT;

procedure PUT(ITEM : in STRING)
is
begin
   PUT(CURRENT_OUTPUT, ITEM);
end PUT;
```

Notes:

After a character is written in the rightmost position of a row, the active position is the first position of the next row.

5.3.7.10. Enabling echo on a terminal

```
procedure SET_ECHO(TERMINAL : in FILE_TYPE;
                   TO       : in BOOLEAN := TRUE);
```

Purpose:

This procedure establishes whether characters which appear in the input terminal file identified by TERMINAL are echoed to its associated output terminal file. When TO is TRUE, each character which appears in the input terminal file is echoed to the output terminal file. When TO is FALSE, each character which appears in the input terminal file is not echoed to its associated output terminal file.

Parameters:

TERMINAL is an open file handle on an input terminal file.

TO indicates whether or not to echo input characters.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or PAGE is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode OUT_FILE or APPEND_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
procedure SET_ECHO(TO : in BOOLEAN := TRUE)
is
begin
    SET_ECHO(CURRENT_INPUT, TO);
end SET_ECHO;
```

5.3.7.11. Querying echo on a terminal

```
function ECHO(TERMINAL : in FILE_TYPE)
        return BOOLEAN;
```

Purpose:

This function returns TRUE if echo is enabled; otherwise it returns FALSE.

Parameters:

TERMINAL is an open file handle on an input terminal file.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or PAGE is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode OUT_FILE or APPEND_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
function ECHO
        return BOOLEAN
is
begin
    return ECHO(CURRENT_INPUT);
end ECHO;
```

5.3.7.12. Determining the number of function keys

```
function MAXIMUM_FUNCTION_KEY(TERMINAL : in FILE_TYPE)
        return NATURAL;
```

Purpose:

This function returns the maximum function key identification number that can be returned by a GET operation in the input terminal file identified by TERMINAL.

Parameters:

TERMINAL is an open file handle on an input terminal file.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or PAGE is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode OUT_FILE or APPEND_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
function MAXIMUM_FUNCTION_KEY
        return NATURAL
is
begin
    return MAXIMUM_FUNCTION_KEY(CURRENT_INPUT);
end MAXIMUM_FUNCTION_KEY;
```

5.3.7.13. Reading a character from a terminal

```
procedure GET(TERMINAL : in    FILE_TYPE;
              ITEM     : out   CHARACTER;
              KEYS     : out   FUNCTION_KEY_DESCRIPTOR);
```

Purpose:

This procedure reads either a single character into ITEM or a single function key identification number into KEYS from the input terminal file identified by TERMINAL.

Parameters:

TERMINAL is an open file handle on an input terminal file.

ITEM is the character that was read.

KEYS describes the function key that was read.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or PAGE is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode OUT_FILE or APPEND_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
procedure GET(ITEM : out CHARACTER;
              KEYS : out FUNCTION_KEY_DESCRIPTOR)
is
begin
  GET(CURRENT_INPUT, ITEM, KEYS);
end GET;
```

Notes:

This procedure will only return function key identification numbers in KEYS if function keys have been enabled (see Section 5.3.5.12). Otherwise the characters in the ASCII character sequence representing the function key will appear one at a time in ITEM.

5.3.7.14. Reading all available characters from a terminal

```
procedure GET(TERMINAL : in     FILE_TYPE;
              ITEM     :    out STRING;
              LAST     :    out NATURAL;
              KEYS     :    out FUNCTION_KEY_DESCRIPTOR);
```

Purpose:

This procedure successively reads characters and function key identification numbers into ITEM and KEYS respectively until either all positions of ITEM or KEYS are filled or there are no more characters available in the input terminal file. Upon completion, LAST contains the index of the last position in ITEM to contain a character that has been read.

Parameters:

TERMINAL is an open file handle on an input terminal file.

ITEM is a string of the characters that were read.

LAST is the position of the last character read in ITEM.

KEYS is the description of the function key identification numbers that were read.

Exceptions:

USE_ERROR is raised if the file identified by TERMINAL is not the value of the predefined attribute FILE_KIND or PAGE is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

MODE_ERROR

is raised if the file identified by TERMINAL is of mode OUT_FILE or APPEND_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
procedure GET(ITEM : out STRING;
              LAST : out NATURAL;
              KEYS : out FUNCTION_KEY_DESCRIPTOR)
is
begin
   GET(CURRENT_INPUT, ITEM, LAST, KEYS);
end GET;
```

Notes:

This procedure will only return function key identification numbers in KEYS if function keys have been enabled (see Section 5.3.5.11). Otherwise the characters in the ASCII character sequence representing the function key will appear in ITEM. If there are no elements available for reading from the input terminal file, then LAST has a value one less than ITEM'FIRST and FUNCTION_KEY_COUNT(KEYS) (see Section 5.3.7.15) is equal to zero.

5.3.7.15. Determining the number of function keys that were read

```
function FUNCTION_KEY_COUNT(KEYS : in FUNCTION_KEY_DESCRIPTOR)
         return NATURAL;
```

Purpose:

This function returns the number of function keys described in KEYS.

Parameters:

KEYS is the function key descriptor being queried.

Exceptions:

None.

5.3.7.16. Determining function key usage

```
procedure FUNCTION_KEY(KEYS           : in    FUNCTION_KEY_DESCRIPTOR;
                       INDEX          : in    POSITIVE;
                       KEY_IDENTIFIER :   out POSITIVE;
                       POSITION       :   out NATURAL);
```

Purpose:

This procedure returns the identification number of a function key and the position in the string (read at the same time as the function keys) of the character following the function key.

Parameters:

KEYS is the description of the function key numbers that were read.

INDEX is the index in KEYS of the function key to be queried.

KEY_IDENTIFIER
is the identification number of a function key.

POSITION is the position of the character read after the function key.

Exceptions:

CONSTRAINT_ERROR
is raised if INDEX is greater than FUNCTION_KEY_COUNT(KEYS) .

5.3.7.17. Determining the name of a function key

```
procedure FUNCTION_KEY_NAME(TERMINAL       : in   FILE_TYPE;
                            KEY_IDENTIFIER : in   POSITIVE;
                            KEY_NAME       :  out STRING;
                            LAST           :  out POSITIVE);
```

Purpose:

This function returns (in KEY_NAME) the string identification of the function key designated by KEY_IDENTIFIER. It also returns the index of the last character of the function key name in LAST.

Parameters:

TERMINAL is an open file handle on an input terminal file.

KEY_IDENTIFIER
is the identification number of a function key.

KEY_NAME is the name of the key designated by KEY_IDENTIFIER.

LAST is the position in KEY_NAME of the last character of the function key name.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or PAGE is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode OUT_FILE or APPEND_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
: is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

CONSTRAINT_ERROR
: is raised if the value of KEY_IDENTIFIER is greater than MAXIMUM_FUNCTION_KEY(TERMINAL) or the string identification of the function key sequence is longer that the string KEY_NAME.

Additional Interface:

```
procedure FUNCTION_KEY_NAME (KEY_IDENTIFIER : in     POSITIVE;
                             KEY_NAME       : out STRING;
                             LAST           : out POSITIVE;)
is
begin
   FUNCTION_KEY_NAME(CURRENT_INPUT,
                     KEY_IDENTIFIER, KEY_NAME, LAST);
end FUNCTION_KEY_NAME;
```

5.3.7.18. Deleting characters

```
procedure DELETE_CHARACTER(TERMINAL:  in FILE_TYPE;
                           COUNT:     in POSITIVE := 1);
```

Purpose:

This procedure deletes COUNT characters on the active line starting at the active position and advancing toward the end position. Adjacent characters to the right of the active position are shifted left. Open space on the right is filled with space characters. The active position is not changed.

Parameters:

TERMINAL — is an open file handle on an output terminal file.

COUNT — is the number of characters to be deleted.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or PAGE is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL, or if the value of COUNT is greater than the number of positions in the active line including and following the active position.

MODE_ERROR
: is raised if TERMINAL is of mode IN_FILE.

STATUS_ERROR
: is raised if the file identified by TERMINAL is not an open file handle.

DEVICE_ERROR
: is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
procedure DELETE_CHARACTER(COUNT:  in POSITIVE :=1)
is
begin
   DELETE_CHARACTER(CURRENT_OUTPUT, COUNT);
end DELETE_CHARACTER;
```

5.3.7.19. Deleting lines

```
procedure DELETE_LINE(TERMINAL:  in FILE_TYPE;
                      COUNT:     in POSITIVE:=1);
```

Purpose:

This procedure deletes COUNT lines starting at the active position and advancing toward the end position. Adjacent lines are shifted from the bottom toward the active position. Open space at the bottom of the display is filled with erased lines. The active position is not changed.

Parameters:

TERMINAL is an open file handle on an output terminal file.

COUNT is the number of lines to be deleted.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or PAGE is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL, or if the value of COUNT is greater than the number of rows including and following the active position.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode IN_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
procedure DELETE_LINE(COUNT:  in POSITIVE := 1)
is
begin
   DELETE_LINE(CURRENT_OUTPUT, COUNT);
end DELETE_LINE;
```

5.3.7.20. Erasing characters in a line

```
procedure ERASE_CHARACTER(TERMINAL:  in FILE_TYPE;
                          COUNT:     in POSITIVE := 1);
```

Purpose:

This procedure replaces COUNT characters on the active line with space characters starting at the active position and advancing toward the end position. The active position is not changed.

Parameters:

TERMINAL is an open file handle on an output terminal file.

COUNT is the number of characters to be erased

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or PAGE is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL, or if the value of COUNT is greater than the number of positions in the active line including and after the active position.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode IN_FILE.

STATUS_ERROR
is raised if the file identified by TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interaces:

```
procedure ERASE_CHARACTER(COUNT : in POSITIVE :=1)
is
begin
   ERASE_CHARACTER(CURRENT_OUTPUT, COUNT);
end ERASE_CHARACTER;
```

5.3.7.21. Erasing characters in a display

```
procedure ERASE_IN_DISPLAY(TERMINAL:  in FILE_TYPE;
                           SELECTION: in SELECT_ENUMERATION);
```

Purpose:

This procedure erases the characters in the display as determined by the active position and the given SELECTION (including the active position). After erasure erased positions have space characters. The active position is not changed.

Parameters:

TERMINAL is an open file handle on an output terminal file.

SELECTION is the portion of the display to be erased.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or PAGE is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode IN_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
procedure ERASE_IN_DISPLAY(SELECTION : in SELECT_ENUMERATION)
is
begin
   ERASE_IN_DISPLAY(CURRENT_OUTPUT, SELECTION);
end ERASE_IN_DISPLAY;
```

5.3.7.22. Erasing characters in a line

```
procedure ERASE_IN_LINE(TERMINAL:   in FILE_TYPE;
                        SELECTION:  in SELECT_ENUMERATION);
```

Purpose:

This procedure erases the characters in the active line as determined by the active position and the given SELECTION (including the active position). After erasure erased positions have space characters. The active position is not changed.

Parameters:

TERMINAL is an open file handle on an output terminal file.

SELECTION is the portion of the line to be erased.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or PAGE is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL, or if the value of COUNT is greater than the number of columns including and following the active position.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode IN_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
procedure ERASE_IN_LINE(SELECTION:  in SELECT_ENUMERATION)
 is
begin
   ERASE_IN_LINE(CURRENT_OUTPUT, SELECTION);
end ERASE_IN_LINE;
```

5.3.7.23. Inserting space characters in a line

```
procedure INSERT_SPACE(TERMINAL:  in FILE_TYPE;
                       COUNT:     in POSITIVE := 1);
```

Purpose:

This procedure inserts COUNT space characters into the active line at the active position. The character at the active position and adjacent characters are shifted to the right. The COUNT rightmost characters on the line are lost. The active position is not changed.

Parameters:

TERMINAL is an open file handle on an output terminal file.

COUNT is the number of space characters to be inserted.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or PAGE is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL, or if the value of COUNT is greater than the number of columns including and following the active position.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode IN_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
procedure INSERT_SPACE(COUNT: in POSITIVE := 1)
is
begin
   INSERT_SPACE(CURRENT_OUTPUT, COUNT);
end INSERT_SPACE;
```

5.3.7.24. Inserting blank lines in the output terminal file

```
procedure INSERT_LINE(TERMINAL: in FILE_TYPE;
                      COUNT:    in POSITIVE := 1);
```

Purpose:

This procedure inserts COUNT blank lines into the output terminal file at the active line. The lines at and below the active position are shifted down. The COUNT bottom lines of the display are lost. The active line is not changed. The column of the active position is changed to one.

Parameters:

TERMINAL is an open file handle on an output terminal file.

COUNT is the number of blank lines to be inserted.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or PAGE is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL, or the value of COUNT is greater than the number of rows including and following the active position.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode IN_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
procedure INSERT_LINE(COUNT: in POSITIVE:= 1)
is
begin
   INSERT_LINE(CURRENT_OUTPUT, COUNT);
end INSERT_LINE;
```

5.3.7.25. Determining graphic rendition support

```
function GRAPHIC_RENDITION_SUPPORT(TERMINAL:  in FILE_TYPE;
                                   RENDITION: in GRAPHIC_RENDITION_ARRAY)

        return BOOLEAN;
```

Purpose:

This function returns TRUE if the RENDITION of combined graphic renditions is supported by the physical terminal associated with the output terminal file identified by TERMINAL; otherwise it returns FALSE.

Parameters:

TERMINAL is an open file handle on an output terminal file.

RENDITION is a combination of graphic renditions.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or PAGE is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL, or if the selected graphic renditions are not supported by the physical terminal associated with the output terminal file identified by TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode IN_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
function GRAPHIC_RENDITION_SUPPORT(RENDITION:
                                   in GRAPHIC_RENDITION_ARRAY)
    return BOOLEAN
is
begin
   return GRAPHIC_RENDITION_SUPPORT(CURRENT_OUTPUT, RENDITION);
end GRAPHIC_RENDITION_SUPPORT;
```

5.3.7.26. Selecting the graphic rendition

```
procedure SELECT_GRAPHIC_RENDITION(TERMINAL:  in FILE_TYPE;
                                   RENDITION: in GRAPHIC_RENDITION_ARRAY
                                      := DEFAULT_GRAPHIC_RENDITION);
```

Purpose:

This procedure sets the graphic rendition for subsequent characters to be output to the output terminal file.

Parameters:

TERMINAL is an open file handle on an output terminal file.

RENDITION is the graphic rendition to be used in subsequent output operations.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or PAGE is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL, or if the selected graphic renditions are not supported by the physical terminal associated with the output terminal file identified by TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode IN_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
procedure SELECT_GRAPHIC_RENDITION(RENDITION : in
                                   GRAPHIC_RENDITION_ARRAY :=
                                   DEFAULT_GRAPHIC_RENDITION)
is
begin
   SELECT_GRAPHIC_RENDITION(CURRENT_OUTPUT, RENDITION);
end SELECT_GRAPHIC_RENDITION;
```

5.3.8. Package FORM_TERMINAL

This package provides the functionality of a form terminal (e.g., an IBM 327x terminal). A form terminal consists of a single device (inasmuch as a programmer is concerned).

The scenario for usage of a form terminal has two active agents: a process and a user. Each interaction with the form terminal consists of a three step sequence. First, the process creates and writes a form to the terminal. Second, the user modifies the form. Third, the process reads the modified form.

A *form* is a two-dimensional matrix of character positions. The rows of a form are indexed by positive numbers starting with row one at the top of the display. The columns of a form are indexed by positive numbers starting with column one at the left side of the form. The position identified by row one, column one, is called the *start position* of the form. The position with the highest row and column index term is called the *end position* of the form.

The position at which an operation is to be performed is called the *active position*. The active position is said to advance toward the end position of the form when the indices of its position are

incremented. The column index is incremented until it attains the highest value permitted for the form. The next position is determined by incrementing the row index of the active position and resetting the column index to 1.

A form is divided into *qualified areas*. A qualified area identifies a contiguous group of positions that share a common set of characteristics. A qualified area begins at the position designated by an *area qualifier* and ends at the position preceding the next area qualifier toward the end of the form. Depending on the form, the position of the area qualifier may or may not be considered to be in a qualified area. The characteristics of a qualified area consist of such things as protection (from modification by the user), display renditions (e.g., intensity), and permissible values (e.g., numeric only, alphabetic only). Each position in a qualified area contains a single printable ASCII character.

5.3.8.1. Types and subtypes

```
type AREA_INTENSITY is
    (NONE,
     NORMAL,
     HIGH);

type AREA_PROTECTION is
    (UNPROTECTED,
     PROTECTED);

type AREA_INPUT is
    (GRAPHIC_CHARACTERS,
     NUMERICS,
     ALPHABETICS);

type AREA_VALUE is
    (NO_FILL,
     FILL_WITH_ZEROES,
     FILL_WITH_SPACES);

type FORM_TYPE
   (ROW                            : POSITIVE;
    COLUMN                         : POSITIVE;
    AREA_QUALIFIER_REQUIRES_SPACE  : BOOLEAN)
  is private;

subtype FILE_TYPE is CAIS.IO_DEFINITIONS.FILE_TYPE;

subtype PRINTABLE_CHARACTERS is CHARACTER range ' ' .. '~';
```

AREA_INTENSITY indicates the intensity at which the characters in the area should be displayed (NONE indicates that characters are not displayed). AREA_PROTECTION specifies whether the user can modify the contents of the area when the form has been activated. AREA_INPUT specifies the valid characters that may be entered by the user; GRAPHIC_CHARACTERS indicates that any printable character may be entered. AREA_VALUE indicates the initial value that the area should have when activated; NO_FILL indicates that the value has been specified by a previous PUT statement. FORM_TYPE describes characteristics of forms. FILE_TYPE describes the type for file handles. PRINTABLE_CHARACTERS describes the characters that can be output to a form terminal.

5.3.8.2. Determining the number of function keys

```
function MAXIMUM_FUNCTION_KEY(TERMINAL:  in FILE_TYPE)
        return NATURAL;
```

Purpose:

This function returns the maximum function key identifier that can be returned by the function TERMINATION_KEY (see Section 5.3.8.13).

Parameters:

TERMINAL is an open file handle on a terminal file.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or FORM is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

MODE_ERROR
is raised if the file identified by TERMINAL is of mode OUT_FILE or APPEND_FILE.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
function MAXIMUM_FUNCTION_KEY return NATURAL
is
begin
    return MAXIMUM_FUNCTION_KEY(CURRENT_INPUT);
end MAXIMUM_FUNCTION_KEY;
```

5.3.8.3. Defining a qualified area

```
procedure DEFINE_QUALIFIED_AREA
   (FORM:          in out FORM_TYPE;
    INTENSITY:     in     AREA_INTENSITY := NORMAL;
    PROTECTION:    in     AREA_PROTECTION := PROTECTED;
    INPUT:         in     AREA_INPUT := GRAPHIC_CHARACTERS;
    VALUE:         in     AREA_VALUE := NO_FILL);
```

Purpose:

This procedure places an area qualifier with the designated attributes at the active position of the form. A qualified area consists of the character positions between two area qualifiers. The area is qualified by the area qualifier that precedes the area. A qualified area may or may not include the position of its area qualifier.

Parameters:

FORM is the form on which the qualified area is being defined.

INTENSITY indicates the intensity at which the qualified area is to be displayed.

PROTECTION indicates the protection for the qualified area.

INPUT indicates the permissible input characters for the qualified area.

VALUE indicates the initial value of the qualified area.

Exceptions:

STATUS_ERROR
is raised if the active position is already defined as an area qualifier.

5.3.8.4. Removing an area qualifier

```
procedure REMOVE_AREA_QUALIFIER(FORM:    in out FORM_TYPE);
```

Purpose:
This procedure removes an area qualifier from the active position of the form.

Parameters:

FORM is the form from which the qualified area is to be removed.

Exceptions:

USE_ERROR is raised if the active position does not have an area qualifier.

STATUS_ERROR
is raised if the active position does not contain an area qualifier.

5.3.8.5. Changing the active position

```
procedure SET_POSITION(FORM:       in out FORM_TYPE;
                       POSITION:   in     POSITION_TYPE);
```

Purpose:
This procedure indicates the position on the form that is to become the active position.

Parameters:

FORM is the form on which to change the active position.

POSITION is the new active position on the form.

Exceptions:

LAYOUT_ERROR
is raised if POSITION does not identify a position in FORM.

5.3.8.6. Moving to the next qualified area

```
procedure NEXT_QUALIFIED_AREA(FORM:  in out FORM_TYPE;
                              COUNT: in     POSITIVE := 1);
```

Purpose:

This procedure advances the active position COUNT qualified areas toward the end of the form.

Parameters:

FORM — is the form on which the active position is being advanced.

COUNT — is the number of qualified areas the active position is to be advanced.

Exceptions:

USE_ERROR — is raised if FORM has fewer than COUNT qualified areas after the active position.

5.3.8.7. Writing to a form

```
procedure PUT(FORM: in out FORM_TYPE;
              ITEM: in     PRINTABLE_CHARACTER);
```

Purpose:

This procedure places ITEM at the active position of FORM and advances the active position one position toward the end position. If the active position is the end position, the active position is not changed.

Parameters:

FORM — is the form being written.

ITEM — is the character to be written to the form.

Exceptions:

USE_ERROR — is raised if the active position contains an area qualifier and AREA_QUALIFIER_REQUIRES_SPACE of FORM was set to TRUE.

Additional interface:

```
procedure PUT(FORM: in out FORM_TYPE;
              ITEM: in     STRING)
is
begin
   for INDEX in ITEM'FIRST .. ITEM'LAST loop
      PUT(FORM, ITEM(INDEX));
   end loop;
end PUT;
```

5.3.8.8. Erasing a qualified area

```
procedure ERASE_AREA(FORM:   in out FORM_TYPE);
```

Purpose:

This procedure places space characters in all positions of the area in which the active position of the form is located.

Parameters:

FORM — is the form on which the qualified area is being erased.

Exceptions:

STATUS_ERROR
is raised if no area qualifiers have been defined for FORM.

5.3.8.9. Erasing a form

```
procedure ERASE_FORM(FORM:   in out FORM_TYPE);
```

Purpose:

This procedure removes all area qualifiers and places SPACE characters in all positions of the form.

Parameters:

FORM — is the form to be erased.

Exceptions:

None.

5.3.8.10. Activating a form on a terminal

```
procedure ACTIVATE(TERMINAL:  in      FILE_TYPE;
                   FORM:      in out  FORM_TYPE);
```

Purpose:

This procedure activates the form on the terminal. The contents of the terminal file is modified to reflect the contents of the form. When the user of the terminal enters a termination key, the modified contents of the terminal file is copied back to the form and returned. This operation may not result in the modification of protected areas.

Parameters:

TERMINAL — is an open file handle on a terminal file.

FORM — is the form to be activated.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or FORM is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

5.3.8.11. Reading from a form

```
procedure GET(FORM:  in out FORM_TYPE;
              ITEM:     out PRINTABLE_CHARACTER);
```

Purpose:

This procedure reads a character from FORM at the active position and advances the active position forward one position (unless the active position is the end position). An area qualifier (on a form on which the area qualifier requires space) is read as the SPACE character.

Parameters:

FORM	is the form to be read.
ITEM	is the character that was read.

Exceptions:

None.

Additional Interface:

```
procedure GET(FORM:  in out FORM_TYPE;
              ITEM:     out STRING)
is
begin
   for INDEX in ITEM'FIRST .. ITEM'LAST loop
      GET(FORM, ITEM(INDEX));
   end loop;
end GET;
```

5.3.8.12. Determining changes to a form

```
function IS_FORM_UPDATED(FORM:  in FORM_TYPE)
         return BOOLEAN;
```

Purpose:

This function returns TRUE if the value of any position on the form was modified during the last activate operation in which the form was used; otherwise it returns FALSE.

Parameters:

FORM	is the form to be queried.

Exceptions:

None.

5.3.8.13. Determining the termination key

```
function TERMINATION_KEY(FORM: in FORM_TYPE)
         return NATURAL;
```

Purpose:

This function returns a number that indicates which (implementation-dependent) key terminated the ACTIVATE procedure for the FORM. A value of zero indicates the normal termination key (e.g., the ENTER key).

Parameters:

FORM is the form to be queried.

Exceptions:

None.

5.3.8.14. Determining the size of a form

```
function FORM_SIZE(FORM: in FORM_TYPE)
         return POSITION_TYPE;
```

Purpose:

This function returns the position of the last column of the last row of the form.

Parameters:

FORM is the form to be queried.

Exceptions:

None.

5.3.8.15. Determining the size of a terminal

```
function TERMINAL_SIZE(TERMINAL: in FILE_TYPE)
         return POSITION_TYPE;
```

Purpose:

This function returns the position of the last column of the last row of the terminal file.

Parameters:

TERMINAL is an open file handle on a terminal file.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or FORM is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the paramete.: TERMINAL.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
function TERMINAL_SIZE
        return POSITION_TYPE
is
begin
    return TERMINAL_SIZE(CURRENT_OUTPUT);
end TERMINAL_SIZE;
```

5.3.8.16. Determining if the area qualifier requires space in the form

```
function AREA_QUALIFIER_REQUIRES_SPACE(FORM:  in FORM_TYPE)
        return BOOLEAN;
```

Purpose:

This function returns TRUE if the area qualifier requires space in the form; otherwise it returns FALSE.

Parameters:

FORM is the form to be queried.

Exceptions:

None.

5.3.8.17. Determining if the area qualifier requires space on a terminal

```
function AREA_QUALIFIER_REQUIRES_SPACE(TERMINAL:  in FILE_TYPE)
        return BOOLEAN;
```

Purpose:

This function returns TRUE if the area qualifier requires space on the physical terminal associated with the terminal file identified by TERMINAL; otherwise it returns FALSE.

Parameters:

TERMINAL is an open file handle on a terminal file.

Exceptions:

USE_ERROR is raised if TERMINAL is not the value of the predefined attribute FILE_KIND or FORM is not a value of the predefined attribute TERMINAL_KIND of the file node associated with the file identified by the parameter TERMINAL.

STATUS_ERROR
is raised if TERMINAL is not an open file handle.

DEVICE_ERROR

is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Additional Interface:

```
function AREA_QUALIFIER_REQUIRES_SPACE
        return BOOLEAN
is
begin
    return AREA_QUALIFIER_REQUIRES_SPACE(CURRENT_OUTPUT);
end AREA_QUALIFIER_REQUIRES_SPACE;
```

5.3.9. Package MAGNETIC_TAPE

This package provides interfaces for the support of input and output operations on both labeled and unlabeled magnetic tapes. Interfaces for labeled tapes are designed with careful consideration of level II of the [ANSI 78] standard. These interfaces only support single-volume magnetic tape files.

To use a tape drive, a file handle on the file representing the tape drive must be obtained (see OPEN in Section 5.3.4.3). The first time a tape is used, it must be initialized either as a labeled tape or as an unlabeled tape. All initialized tapes may be loaded as unlabeled tapes; however, only initialized labeled tapes may be loaded as labeled tapes. Once a tape has been loaded, CAIS.TEXT_IO routines are used to get information to and from the tape.

When information transfer is completed, the tape is unloaded and dismounted using the UNLOAD and DISMOUNT procedures.

Once a tape is dismounted, another tape may be mounted. When the user is finished utilizing the drive, he closes the file handle on the file representing the tape on the drive (see Section 5.3.4).

Magnetic tape drive files can only be created by the implementation. Implementation-defined file characteristics must be supported by the implementation and will include the densities and block sizes supported by the tape drive, whether or not a tape is mounted on the drive and whether the tape was loaded as a labeled or unlabeled tape. Each block of a file may be terminated by zero or more fill characters.

An unlabeled tape is read according to the format:

```
------------------------------------------
    BOT file * file * ... * file **
------------------------------------------
```

where * represents a tape mark, ** represents the logical end of tape, and BOT is the beginning of the tape. For the CAIS, a file on a magnetic tape is either a text file or a label group. A labeled tape may be mounted as an unlabeled tape, which causes each label group to be considered as a file. A *label group* can be one of the following: a volume header label and a file header label, or a file header label, or an end-of-file label.

A labeled tape is read according to the format:

BOT VOL1 HDR * file * EOF * HDR * file * EOF *...* HDR * file * EOF**

---

where * represents a tape mark, ** represents the logical end of tape, BOT is the beginning of the tape, VOL1 is the volume header label, HDR is the file header label, and EOF is the end-of-file label.

5.3.9.1. Types and subtypes

```
type TAPE_POSITION is
     (BEGINNING_OF_TAPE,
      PHYSICAL_END_OF_TAPE,
      TAPE_MARK,
      OTHER);


subtype REEL_NAME is STRING;
subtype VOLUME_STRING is STRING(1..6);
subtype FILE_STRING is STRING(1..17);
subtype LABEL_STRING is STRING (1..80);
subtype FILE_TYPE is CAIS.IO_DEFINITIONS.FILE_TYPE;
```

TAPE_POSITION describes the position of the tape on the tape drive; a value of TAPE_MARK means that the tape is positioned just after a tape mark. That is, a read in this position will read the next file or label. A read starting in position TAPE_MARK will only read a tape mark if there are two consecutive tape marks on the tape at this location.

REEL_NAME describes the type used for the external name of a tape (i.e, the name written on the tape container).

VOLUME_STRING and FILE_STRING both have the syntax of an Ada identifier. LABEL_STRING describes the type used for reading volume header labels, file header labels and end-of-file labels. FILE_TYPE describes the type for file handles, which are used for controlling all operations on tape drives.

5.3.9.2. Mounting a tape

```
procedure MOUNT(TAPE_DRIVE: in FILE_TYPE;
                TAPE_NAME:  in REEL_NAME;
                DENSITY:    in POSITIVE);
```

Purpose:

This procedure generates an implementation-defined request that the tape whose external name is TAPE_NAME be mounted on the tape drive represented by the file identified by TAPE_DRIVE. It also requests that the tape drive density be set to DENSITY. Following completion of the requested operations, the function IS_MOUNTED(TAPE_DRIVE) will return TRUE.

Parameters:

TAPE_DRIVE
: is an open file handle on the file representing the tape drive.

TAPE_NAME
: is an external name which identifies the tape to be mounted on the tape drive.

DENSITY is the density in characters per inch (e.g., 800, 1600, 6250).

Exceptions:

USE_ERROR is raised if MAGNETIC_TAPE is not the value of the attribute FILE_KIND of the node associated with the file identified by TAPE_DRIVE or if IS_MOUNTED(TAPE_DRIVE) is TRUE at the time of the call.

STATUS_ERROR
is raised if TAPE_DRIVE is not an open file handle.

DEVICE_ERROR
is raised if this operation cannot be completed because of a malfunction of the underlying system.

5.3.9.3. Loading an unlabeled tape

```
procedure LOAD_UNLABELED(TAPE_DRIVE:  in FILE_TYPE;
                         DENSITY:     in POSITIVE;
                         BLOCK_SIZE:  in POSITIVE);
```

Purpose:

This procedure loads the tape on the tape drive represented by the file identified by TAPE_DRIVE. The tape is positioned at the beginning of tape. The DENSITY is validated against the settings of the tape drive. The block size for subsequent reads and writes is set to the value of BLOCK_SIZE. Following completion of this procedure, the function IS_LOADED(TAPE_DRIVE) will return true.

Parameters:

TAPE_DRIVE is an open file handle on the file representing the drive.

DENSITY is the density in characters per inch (e.g., 800, 1600, 6250) at which the tape is to be read or written.

BLOCK_SIZE is the size of each data block which is to be read from or written to the file identified by TAPE_DRIVE.

Exceptions:

USE_ERROR is raised if IS_LOADED(TAPE_DRIVE) is TRUE or IS_MOUNTED(TAPE_DRIVE) is FALSE at the time of the call, or if DENSITY is not the same as the density of the tape drive, or if the block size cannot be supported by the tape drive.

STATUS_ERROR
is raised if TAPE_DRIVE is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system or if the tape is uninitialized.

5.3.9.4. Initializing an unlabeled tape

```
procedure INITIALIZE_UNLABELED(TAPE_DRIVE:  in FILE_TYPE;
                               DENSITY:     in POSITIVE;
                               BLOCK_SIZE:  in POSITIVE);
```

Purpose:

This procedure initializes the tape which is mounted on the tape drive represented by the file identified by TAPE_DRIVE. The tape drive must have been mounted but not loaded. If the tape is not positioned at the beginning of tape, then the tape is rewound to it. Two adjacent tape marks are written following the beginning of tape mark.The DENSITY is validated against the settings of the tape drive. The block sign for subsequent reads and writes is set to the value of BLOCK_SIZE. The tape is positioned at the beginning of the tape. Initialization places the logical end of tape at the beginning of the tape. The resulting tape is an initialized unlabeled tape.

Parameters:

TAPE_DRIVE is an open file handle on the file representing the drive.

DENSITY is the density in characters per inch (e.g., 800, 1600, 6250)

BLOCK_SIZE is the size of each data block which is to be read from or written to the file identified by TAPE_DRIVE.

Exceptions:

USE_ERROR is raised if MAGNETIC_TAPE is not the value of the attribute FILE_KIND of the node associated with the file identified by TAPE_DRIVE, or DENSITY is not the same as the density of the tape drive, or if the block size cannot be supported by the tape drive.

MODE_ERROR
is raised if the file identified by TAPE_DRIVE is of mode IN_FILE.

STATUS_ERROR
is raised if TAPE_DRIVE is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Notes:

The first file is written immediately following the beginning of tape mark, overwriting the two tape marks written at initialization.

5.3.9.5. Loading a labeled tape

```
procedure LOAD_LABELED(TAPE_DRIVE:         in FILE_TYPE;
                       VOLUME_IDENTIFIER:  in VOLUME_STRING;
                       DENSITY:            in POSITIVE;
                       BLOCK_SIZE:         in POSITIVE);
```

Purpose:

This procedure loads the labeled tape on the tape drive represented by the file identified by TAPE_DRIVE. It checks to see that the first block on the volume is a volume header label ("VOL1"). The VOLUME_IDENTIFIER in the parameter list must match the volume identifier in the volume header label on the tape. The tape is positioned at the beginning of tape. The DENSITY is validated against the settings of the tape drive. The block size for subsequent reads and writes is set to the value of BLOCK_SIZE. Following completion of this procedure, the function IS_LOADED(TAPE_DRIVE) (see Section 5.3.9.6) will return TRUE.

Parameters:

TAPE_DRIVE is an open file handle on the file representing the tape drive.

VOLUME_IDENTIFIER
is the name which identifies the volume.

DENSITY is the density in characters per inch (e.g., 800, 1600, 6250) at which the tape is to be read or written.

BLOCK_SIZE is the size of each data block which is to be read from or written to the file identified by TAPE_DRIVE.

Exceptions:

USE_ERROR is raised if IS_LOADED(TAPE_DRIVE) is TRUE or IS_MOUNTED(TAPE_DRIVE) is FALSE prior to the call, or the VOLUME_IDENTIFIER does not match the volume identifier in the volume header label on the tape, or if the tape is unlabeled. USE_ERROR is also raised if the block size cannot be supported by the tape drive or, if DENSITY is not the same as the density of the tape drive.

STATUS_ERROR
is raised if TAPE_DRIVE is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

5.3.9.6. Initializing a labeled tape

```
procedure INITIALIZE_LABELED(TAPE_DRIVE:        in FILE_TYPE;
                             VOLUME_IDENTIFIER: in VOLUME_STRING;
                             DENSITY:           in POSITIVE;
                             BLOCK_SIZE:        in POSITIVE;
                             ACCESSIBILITY:     in CHARACTER:=' ');
```

Purpose:

This procedure initializes the tape which is mounted on the tape drive represented by the file identified by TAPE_DRIVE. The tape drive must have been mounted but not loaded. If the tape is not positioned at the beginning of tape, then the tape is rewound to it. A volume header label is written, followed by two tape marks. The tape is positioned following the volume header label. Initialization places the logical end of tape after the volume header label. The DENSITY is validated against the settings of the tape drive. The block size for subsequent reads and writes is set to the value of BLOCK_SIZE. The resulting tape is an initialized labeled tape.

Parameters:

TAPE_DRIVE is an open file handle on the file representing the tape drive.

VOLUME_IDENTIFIER
is a six-character string giving the volume name.

DENSITY is the density in characters per inch (e.g., 800, 1600, 6250) at which the tape is to be read or written.

BLOCK_SIZE is the size of each data block which is to be read from or written to the file identified by TAPE_DRIVE.

ACCESSIBILITY
is a character representing restrictions on access to the tape, in accordance with [ANSI 78]; a SPACE indicates no access control.

Exceptions:

USE_ERROR is raised if MAGNETIC_TAPE is not the value of the attribute FILE_KIND of the node associated with the file identified by TAPE_DRIVE, or the VOLUME_IDENTIFIER does not match the volume identifier in the volume header label on the tape, or if the tape is unlabeled.

MODE_ERROR
is raised if the file identified by TAPE_DRIVE is of mode IN_FILE.

STATUS_ERROR
is raised if TAPE_DRIVE is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Notes:

When the first file is written on the tape, the file header label will follow the volume header created by this procedure.

5.3.9.7. Unloading a tape

procedure UNLOAD(TAPE_DRIVE: **in** FILE_TYPE);

Purpose:

This procedure unloads the tape on the tape drive represented by the file identified by TAPE_DRIVE. It rewinds the tape to the beginning of tape and releases the established block size. Following completion of this procedure, the function IS_LOADED(TAPE_DRIVE) will return FALSE.

Parameters:

TAPE_DRIVE is an open file handle on the file representing the tape drive.

Exceptions:

STATUS_ERROR
is raised if TAPE_DRIVE is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

Notes:

If no conditions for these exceptions exist and there is no tape loaded on the tape drive, this procedure has no effect.

5.3.9.8. Dismounting a tape

```
procedure DISMOUNT(TAPE_DRIVE: in FILE_TYPE);
```

Purpose:

This procedure generates an implementation-defined request that the tape on the tape drive represented by the file identified by TAPE_DRIVE be removed from the drive. It makes the tape available for removal and releases the established density. Following the completion of this procedure, the function IS_MOUNTED (TAPE_DRIVE) will return FALSE.

Parameters:

TAPE_DRIVE is an open file handle on the file representing the tape drive.

Exceptions:

USE_ERROR is raised if MAGNETIC_TAPE is not the value of the attribute FILE_KIND of the node associated with the file identified by TAPE_DRIVE.

STATUS_ERROR
is raised if TAPE_DRIVE is not an open file handle.

DEVICE_ERROR
is raised if this operation cannot be completed because of a malfunction of the underlying system.

Notes:

If no conditions for these exceptions exist and there is no tape mounted on the tape drive, this procedure has no effect.

5.3.9.9. Determining if the tape drive is loaded

```
function IS_LOADED(TAPE_DRIVE: in FILE_TYPE)
        return BOOLEAN;
```

Purpose:

This function returns TRUE if the tape on the tape drive represented by the file identified by TAPE_DRIVE has been loaded; otherwise it returns FALSE.

Parameters:

TAPE_DRIVE is an open file handle on the file representing the tape drive.

Exceptions:

USE_ERROR is raised if MAGNETIC_TAPE is not the value of the attribute FILE_KIND of the node associated with the file identified by TAPE_DRIVE.

STATUS_ERROR
is raised if TAPE_DRIVE is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

5.3.9.10. Determining if a tape is mounted

```
function IS_MOUNTED(TAPE_DRIVE:  in FILE_TYPE)
         return BOOLEAN;
```

Purpose:

This function returns TRUE if a tape is mounted on the tape drive represented by the file identified by TAPE_DRIVE; otherwise it returns FALSE.

Parameters:

TAPE_DRIVE is an open file handle on the file representing the tape drive.

Exceptions:

USE_ERROR is raised if MAGNETIC_TAPE is not the value of the attribute FILE_KIND of the node associated with the file identified by TAPE_DRIVE.

STATUS_ERROR
is raised if TAPE_DRIVE is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

5.3.9.11. Determining the position of the tape

```
function TAPE_STATUS(TAPE_DRIVE:  in FILE_TYPE)
         return TAPE_POSITION;
```

Purpose:

This function returns current tape position information.

Parameters:

TAPE_DRIVE is an open file handle on the file representing the tape drive.

Exceptions:

USE_ERROR is raised if MAGNETIC_TAPE is not the value of the attribute FILE_KIND of the node associated with the file identified by TAPE_DRIVE.

STATUS_ERROR
is raised if TAPE_DRIVE is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

5.3.9.12. Rewinding the tape

```
procedure REWIND_TAPE(TAPE_DRIVE:  in FILE_TYPE);
```

Purpose:

This procedure positions the tape at the beginning of tape.

Parameters:

TAPE_DRIVE is an open file handle on the file representing the tape drive.

Exceptions:

USE_ERROR is raised if MAGNETIC_TAPE is not the value of the attribute FILE_KIND of the node associated with the file identified by TAPE_DRIVE.

STATUS_ERROR
is raised if TAPE_DRIVE is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

5.3.9.13. Skipping tape marks

```
procedure SKIP_TAPE_MARKS(TAPE_DRIVE:  in     FILE_TYPE;
                          NUMBER:      in     INTEGER:=1;
                          TAPE_STATE:      out TAPE_POSITION);
```

Purpose:

This procedure provides a method of skipping over tape marks. A positive NUMBER indicates forward skipping, while a negative NUMBER indicates backward skipping. If NUMBER is zero, the tape position does not change.

Following a call to SKIP_TAPE_MARKS, if NUMBER is positive, the tape is positioned immediately following the appropriate tape mark. Following a call to SKIP_TAPE_MARKS, if NUMBER is negative, the tape is positioned immediately preceding the appropriate tape mark (i.e., at the end of a file or label). If two consecutive tape marks are encountered, the tape is positioned immediately following the second one, even if fewer than NUMBER tape marks have been skipped. Additionally, the current column, current line and current page numbers (see [LRM] 14.3) are set to one.

Parameters:

TAPE_DRIVE is an open file handle on the file representing the tape drive.

NUMBER is the number of tape marks to skip and the direction of movement.

TAPE_STATE
is the position of the tape after skipping the specified number of tape marks.

Exceptions:

USE_ERROR is raised if MAGNETIC_TAPE is not the value of the attribute FILE_KIND of the node associated with the file identified by TAPE_DRIVE.

STATUS_ERROR
is raised if TAPE_DRIVE is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

5.3.9.14. Writing a tape mark

```
procedure WRITE_TAPE_MARK(TAPE_DRIVE:  in   FILE_TYPE;
                          NUMBER:      in   POSITIVE := 1;
                          TAPE_STATE:  out  TAPE_POSITION);
```

Purpose:

This procedure writes NUMBER consecutive tape marks on the tape which is mounted on the tape drive represented by the file identified by TAPE_DRIVE. The tape is stopped following the last tape mark written.

Parameters:

TAPE_DRIVE is an open file handle on the file representing the tape drive.

NUMBER is the number of consecutive tape marks to be written.

TAPE_STATE
is the new position of the tape.

Exceptions:

USE_ERROR is raised if MAGNETIC_TAPE is not the value of the attribute FILE_KIND of the node associated with the file identified by TAPE_DRIVE or if IS_LOADED(TAPE_DRIVE) is FALSE.

MODE_ERROR
is raised if the file identified by TAPE_DRIVE is of mode IN_FILE.

STATUS_ERROR
is raised if TAPE_DRIVE is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

5.3.9.15. Writing a volume header label

```
procedure VOLUME_HEADER(TAPE_DRIVE:          in FILE_TYPE;
                        VOLUME_IDENTIFIER:   in VOLUME_STRING;
                        ACCESSIBILITY:       in CHARACTER :=' ');
```

Purpose:

This procedure writes a volume header label, as described in TABLE XI on the tape loaded on the tape drive represented by the file identified by TAPE_DRIVE.

The accessibility character is obtained from the ACCESSIBILITY parameter. The owner identification is the user name indicated by 'CURRENT_USER. The Label-Standard Version, which is 3, indicates the ANSI standard version to which these labels conform.

Table XI. Volume header label

Character Position	Field Name	Content
1 to 3	Label Identifier	VOL
4	Label Number	1
5 to 10	Volume Identifier	Assigned permanently by owner to identify volume
11	Accessibility	Indicates restrictions on access to the information on the volume
12 to 37	Reserved for Future Standardization	Spaces
38 to 51	Owner Identity	Identifies owner of volume
52 to 79	Reserved for Future Standardization	Spaces
80	Label-Standard Version	Indicates the version of the ANSI standard to which the labels and data formats on this volume conform

Parameters:

TAPE_DRIVE is an open file handle on the file representing the tape drive.

VOLUME_IDENTIFIER
is a six-character string giving the volume name.

ACCESSIBILITY
is a character representing restrictions on access to the tape, in accordance with [ANSI 78]; a SPACE indicates no access control.

Exceptions:

USE_ERROR is raised if MAGNETIC_TAPE is not the value of the attribute FILE_KIND of the node associated with the file identified by TAPE_DRIVE. USE_ERROR is also raised if the tape on the tape drive represented by the file identified by TAPE_DRIVE was loaded as an unlabeled tape or if the value of VOLUME_IDENTIFIER does not conform to the syntax of an Ada identifier. USE_ERROR is also raised if IS_LOADED(TAPE_DRIVE) is FALSE at the time of the call.

MODE_ERROR
is raised if the file identified by TAPE_DRIVE is of mode IN_FILE.

STATUS_ERROR
is raised if TAPE_DRIVE is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

5.3.9.16. Writing a file header label

```
procedure FILE_HEADER(TAPE_DRIVE:        in FILE_TYPE;
                      FILE_IDENTIFIER:   in FILE_STRING;
                      EXPIRATION_DATE:   in STRING :=" 99366";
                      ACCESSIBILITY  :   in CHARACTER :=' ');
```

Purpose:

This procedure writes a file header label, as described in TABLE XII, on the tape loaded on the tape drive represented by the file identified by TAPE_DRIVE.

Parameters:

Table XII. File header label

Character Position	Field Name	Content
1 to 3	Label Identifier	HDR
4	Label Number	1
5 to 21	File Identifier	Assigned permanently by system to identify file
22 TO 27	File Set Identifier	The VOLUME_IDENTIFIER in the file set
28 to 31	File Section Number	0001
32 to 35	File Sequence Number	Distinguishes files in a file set. First file in set gets '0001'. For each file after, sequence number is incremented by one base 10.
36 to 39	Generation Number	0001
40 to 41	Generation Version Number	00
42 to 47	Creation Date	Date file header is written
48 to 53	Expiration Date	Date on which file may be overwritten
54	Accessibility	Indicates restrictions on access to information in file
55 to 60	Block COUNT	000000
61 to 73	System Code	Spaces
74 to 80	Reserved for Future Standardization	Spaces

Parameters:

TAPE_DRIVE is an open file handle on the file representing the tape drive.

FILE_IDENTIFIER
is a 17-character string giving the file name.

EXPIRATION_DATE
is a string identifying the date (6 characters ' YYDDD' where YY is the year and DDD is the day (001-366)) the file may be overwritten. When the expiration date is

a space followed by 5 zeroes, the file has expired. ACCESSIBILITY is a character representing restrictions on access to the tape, in accordance with [ANSI 78]; a SPACE indicates no access control.

Exceptions:

USE_ERROR is raised if MAGNETIC_TAPE is not the value of the attribute FILE_KIND of the node associated with the file identified by TAPE_DRIVE. USE_ERROR is also raised if the tape on the tape drive represented by the file identified by TAPE_DRIVE was loaded as an unlabeled tape or if FILE_IDENTIFIER does not conform to the syntax of an Ada identifier. USE_ERROR is also raised if IS_LOADED(TAPE_DRIVE) is FALSE at the time of the call.

MODE_ERROR
is raised if the file identified by TAPE_DRIVE is of mode IN_FILE.

STATUS_ERROR
is raised if TAPE_DRIVE is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

5.3.9.17. Writing an end of file label

procedure `END_FILE_LABEL(TAPE_DRIVE:` **in** `FILE_TYPE);`

Purpose:

This procedure writes an end of file label, as shown in TABLE XIII on the tape loaded on the tape drive represented by the file identified by TAPE_DRIVE.

Table XIII. End of file label

Character Position	Field Name	Contents
1 to 3	Label Identifier	EOF
4	Label Number	1
5 to 54	Same as corresponding fields in file header label	Same as corresponding fields in file header label
55 to 60	Block COUNT	Number of blocks in file
61 to 80	Same as corresponding fields in file header label	Same as corresponding fields in file header label

Parameters:

TAPE_DRIVE is an open file handle on the file representing the tape drive.

Exceptions:

USE_ERROR is raised if MAGNETIC_TAPE is not the value of the attribute FILE_KIND of the node associated with the file identified by TAPE_DRIVE. USE_ERROR is also raised if IS_LOADED(TAPE_DRIVE) is FALSE at the time of call or if the tape on the tape drive represented by the file identified by TAPE_DRIVE was loaded as an unlabeled tape.

MODE_ERROR
is raised if the file identified by TAPE_DRIVE is of mode IN_FILE.

STATUS_ERROR
is raised if TAPE_DRIVE is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system.

5.3.9.18. Reading a label on a labeled tape

```
procedure READ_LABEL(TAPE_DRIVE:  in  FILE_TYPE;
                     LABEL:       out LABEL_STRING);
```

Purpose:

This procedure obtains th first 80 characters of the next available block and returns them in LABEL.

Parameters:

TAPE_DRIVE is an open file handle on the file representing the tape drive.

LABEL is the 80-character string read from the tape.

Exceptions:

USE_ERROR is raised if the attempt to read eighty characters encounters a tape mark or if MAGNETIC_TAPE is not the value of the attribute FILE_KIND of the node associated with the file identified by TAPE_DRIVE or if IS_LOADED(TAPE_DRIVE) is FALSE at the time of the call. USE_ERROR is also raised if the tape on the tape drive represented by the file identified by TAPE_DRIVE was loaded as an unlabeled tape.

STATUS_ERROR
is raised if TAPE_DRIVE is not an open file handle.

DEVICE_ERROR
is raised if an input or output operation cannot be completed because of a malfunction of the underlying system or if the tape is uninitialized.

5.3.10. Package FILE_IMPORT_EXPORT

The CAIS allows a particular CAIS implementation to maintain files separately from files maintained by the host file system. This package provides the capability to transfer files between these two systems.

5.3.10.1. Importing a file

```
procedure IMPORT(NODE:           in NODE_TYPE;
                 HOST_FILE_NAME: in STRING);
```

Purpose:

This procedure searches for a file in the host file system named HOST_FILE_NAME and copies its contents into a CAIS file which is the contents of the node identified by NODE. It also copies any file characteristic information which must be maintained by the CAIS implementation.

Parameters:

NODE is an open node handle on the file node.

HOST_FILE_NAME
is the name of the host file to be copied.

Exceptions:

NAME_ERROR
is raised if the node identified by NODE is inaccessible.

USE_ERROR is raised if HOST_FILE_NAME does not adhere to the required syntax for file names in the host file system or if HOST_FILE_NAME does not exist in the host file system. USE_ERROR is also raised if FILE is not the value of the attribute KIND of the node identified by NODE.

STATUS_ERROR
is raised if NODE is not an open node handle.

INTENT_VIOLATION
is raised if NODE was not opened with an intent establishing the right to write contents.

SECURITY_VIOLATION
is raised if the operation represents a violation of mandatory access controls. SECURITY_VIOLATION is raised only if the conditions for other exceptions are not present.

Additional Interface:

```
procedure IMPORT(NAME:           in NAME_STRING;
                 HOST_FILE_NAME: in STRING)
is
   NODE:NODE_TYPE;
begin
   OPEN(NODE,NAME,(1=>WRITE_CONTENTS));
```

```
        IMPORT(NODE,HOST_FILE_NAME);
        CLOSE(NODE);
    exception
        when others =>
            CLOSE(NODE);
            raise;
    end IMPORT;
```

5.3.10.2. Exporting a file

```
    procedure EXPORT(NODE:              in NODE_TYPE;
                     HOST_FILE_NAME:    in STRING);
```

Purpose:

This procedure creates a new file named HOST_FILE_NAME in the host file system and copies the contents of the file node identified by NODE into it.

Parameters:

NODE is an open node handle on the file node.

HOST_FILE_NAME
is the name of the host file to be created.

Exceptions:

NAME_ERROR
is raised if the node identified by NODE is inaccessible.

USE_ERROR is raised if HOST_FILE_NAME does not adhere to the required syntax for file names in the host file system or if HOST_FILE_NAME cannot be created in the host file system. USE_ERROR is also raised if FILE is not the value of the attribute KIND of the node identified by NODE.

STATUS_ERROR
is raised if NODE is not an open node handle.

INTENT_VIOLATION
is raised if NODE was not opened with an intent establishing the right to read contents.

Additional Interface:

```
    procedure EXPORT(NAME:              in NAME_STRING;
                     HOST_FILE_NAME:    in STRING);
    is
        NODE:NODE_TYPE;
    begin
        OPEN(NODE,NAME,(1=>READ_CONTENTS));
        EXPORT(NODE,HOST_FILE_NAME);
        CLOSE(NODE);
    exception
        when others =>
            CLOSE(NODE);
            raise;
    end EXPORT;
```

5.4. CAIS Utilities

This section defines the abstract data type LIST_TYPE for use by other CAIS interfaces. The value of an entity of type LIST_TYPE (referred to as a *list*) is a linearly ordered set of data elements called *list items*.

It is possible to associate a name with a list item. If no name is associated with a list item, the item is an *unnamed item*. If a name is associated with a list item, the item is a *named item*. A list can either contain all unnamed items, in which case it is called an *unnamed list*, or all named items, in which case it is called a *named list*, but not both. If a list contains all named items, names among these items must be unique. An empty list is a list which contains no items. Such a list is not considered to be either named or unnamed. An empty list can be obtained by using the EMPTY_LIST constant or the DELETE procedure. The type LIST_KIND enumerates these three classifications of lists.

Associated with each list item is a classification, or kind. List items are classified as strings, integers, float numbers, identifiers and lists. The kind of an item is a value of the enumeration type ITEM_KIND. The CAIS interfaces allow, but do not require, an individual implementation of the CAIS to employ efficient mechanisms for representing identifiers as part of lists. Towards this purpose, a private type TOKEN_TYPE is introduced, which allows identifiers to be manipulated as internal representations called *tokens*. Interfaces are provided to transform identifiers in the form of a NAME_STRING into a TOKEN_TYPE and vice versa. NAME_STRING is a subtype of STRING, whose values are assumed to conform to the syntax of Ada identifiers. Tokens are equal if and only if their external representations are equal under string comparison, excepting differences in upper and lower case notation.

The names of list items in a named list may be internally represented as tokens. Overloaded interfaces are provided in the CAIS that allow the names of list items within a named list to be specified by parameters of either NAME_STRING or TOKEN_TYPE type.

The specifications within this package allow for the manipulation of lists which are of unnamed, named or empty kind. If a parameter of an interface specifies an item by position, then that interface may be used with either unnamed lists or named lists. If, however, a parameter specifies an item by name, then the associated interface may only be used with named lists.

Items of a list can be manipulated by:

a. extracting items from a list,

b. replacing or changing values of items in a list, and

c. inserting new items into a list.

These operations are provided by the EXTRACT, REPLACE, and INSERT subprograms, respectively. Packages are provided to allow such operations to be performed directly on strings, identifiers and lists. Operations on the numeric types are provided with generic packages.

The positions in the list where these operations are specified to take place are usually designated by the parameter POSITION. With named lists a particular item can be specified by a name. This is possible since such names by definition are unique. Specifying a particular item by name is only permitted with EXTRACT and REPLACE operations.

Insertion operations can also be performed on sets of items. A set would then effectively constitute a

(sub)list. Operations to delete an item or a set of items are also provided. Insertion and deletion operations will adjust the ordinal positions of items after the inserted or deleted items.

The value of an entity of type LIST_TYPE can be represented externally to the package LIST_UTILITIES as a string. Interfaces are provided to convert between entities of type STRING, containing a string value consistent with the syntax of this external representation, and entities of type LIST_TYPE. An object of type LIST_TYPE has as its initial value the empty list. The BNF for a list's external representation is given in TABLE XIV.

Table XIV. List external representation BNF

```
list ::= named_list
       | unnamed_list
       | empty_list
named_list ::= (named_item { , named_item } )
unnamed_list ::= (item { , item } )
empty_list ::= ()
named_item ::= name_string => item
item ::= list
       | quoted_string
       | integer_number
       | float_number
       | identifier
integer_number ::= integer
float_number ::= decimal_literal
quoted_string ::= string_literal
name_string ::= identifier
```

```
Notation:
 1. Words - syntactic categories
 2. [ ]   - optional items
 3. { }   - an item repeated zero or       times
 4.  |    - separates alternatives
```

The CAIS defines a canonical external string representation for values of type LIST_TYPE. The string subtype LIST_TEXT is used in the CAIS interfaces for string values that adhere to this canonical external representation. This external representation is obtained by applying the TO_TEXT operation to a value of type LIST_TYPE or to a value that is a legal value of a list item.

The canonical external string representation of a value of type LIST_TYPE and of its list items is defined as follows:

a. For an integer list item, the external string representation is the decimal representation of its numeric value without leading zeroes.

b. For a floating point list item, the external string representation is the string image of its numeric value in decimal notation with a format as obtained under implementation-defined settings of the FORE, AFT, and EXP parameters in PUT operations of Ada TEXT_IO (see [LRM] 14.3.8). These settings of FORE, AFT, and EXP must guarantee that quality of the external representation implies equality of the internal representation and vice versa within the limitations imposed by the accuracy of numeric comparisons in Ada.

c. For an identifier list item or the name of a list item, the external string representation is the identifier string in upper case characters.

d. For a quoted string list item, the external string representation is the string literal representing the value of the list item (i.e., the string value enclosed by quotation characters and with inner quotation characters doubled).

e. for a list as a list item, the external string representation is the external representation of the value of the list.

f. for a list, the external string representation of its value is the string representation composed of the external representation of its list items according to the syntax of Table XVII without blanks, format effectors or non-printing characters between the lexical or syntactic constituents of the syntax.

5.4.1. Package LIST_UTILITIES

This package defines types, subtypes, constants, exceptions and general list manipulation interfaces. The latter are supplemented by generic subpackages for the manipulation of list items of numeric type.

5.4.1.1. Types and subtypes

```
type    LIST_TYPE      is limited private;
type    TOKEN_TYPE     is limited private;
type    LIST_KIND      is (UNNAMED, NAMED, EMPTY);
type    ITEM_KIND      is (LIST_ITEM, STRING_ITEM, INTEGER_ITEM,
                           FLOAT_ITEM, IDENTIFIER_ITEM);
subtype LIST_TEXT       is STRING;
subtype NAME_STRING     is STRING;
type    COUNT          is range 0 .. INTEGER'LAST;
subtype POSITION_COUNT is COUNT range COUNT'FIRST
                                        + 1 .. COUNT'LAST;
```

LIST_TYPE describes the type for lists. TOKEN_TYPE describes the type for internal representations of identifiers. LIST_KIND enumerates the kinds of lists. ITEM_KIND enumerates the kinds of list items. LIST_TEXT is the type of a list's external representation. ITEM_TEXT is the type of a list item's external representation. NAME_STRING is the type of an identifier or of an item's name in a named item in its external representation. COUNT describes the type for the length of a list. POSITION_COUNT describes the type for the position of an item in a non-empty list.

EMPTY_LIST : **constant** LIST_TYPE;

EMPTY_LIST is a deferred constant denoting the value of an empty list. Any implementation of the CAIS must ensure that IS_EQUAL(EMPTY_LIST, X) is TRUE for any object X of type LIST_TYPE whose value is an empty list.

SEARCH_ERROR : **exception**;

CONSTRAINT_ERROR: **exception**;

SEARCH_ERROR is raised if a search for an item fails because the item is not present in the list.

CONSTRAINT_ERROR is raised if an attempt is made to convert a value to a numeric type when the value does not satisfy the constraints for that type.

5.4.1.2. Copying a list

```
procedure COPY(TO_LIST:        out LIST_TYPE;
               FROM_LIST:  in      LIST_TYPE);
```

Purpose:

This procedure returns in the parameter TO_LIST a copy of the list value of the parameter FROM_LIST. Subsequent modifications of either list do not affect the other list.

Parameters:

TO_LIST is the list returned as a copy of the value of FROM_LIST.

FROM_LIST is the list to be copied.

Exceptions:

None.

5.4.1.3. Converting to an internal list representation

```
procedure TO_LIST(LIST_STRING: in STRING;)
                  LIST:            out LIST_TYPE);
```

Purpose:

This procedure converts the string representation of a list into the internal list representation. It establishes the list as a named, unnamed, or empty list. The individual list items are classified according to their external representation. For a numeric item value, the item is classified as an integer item if the numeric value can be interpreted as a literal of universal_integer type; otherwise, the numeric item is classified as a floating point item. Blanks, format effectors and non-printing characters are allowed in the value of the parameter LIST_STRING.

Parameters:

LIST_STRING
is the string to be interpreted as a list value.

LIST is the list built and returned according to the contents of LIST_STRING.

Exceptions:

USE_ERROR is raised if the value of the parameter LIST_STRING does not conform to the syntax of TABLE XIV. Blanks, format effectors and non-printing characters are allowed between lexical or syntactic elements of this syntax.

CONSTRAINT_ERROR
is raised if a numeric literal in the LIST_STRING parameter designates a value which cannot be represented as the value of an item in the LIST result.

5.4.1.4. Converting to an external list representation

```
function TO_TEXT (LIST_ITEM: in LIST_TYPE)
        return LIST_TEXT;
```

Purpose:

This function returns the external representation of the value of the LIST_ITEM parameter. The representation is the string representation defined in Section 5.4.

Parameters:

LIST_ITEM is the list to be converted.

Exceptions:

None.

5.4.1.5. Determining the equality of two lists

```
function IS_EQUAL(LIST1:  in LIST_TYPE;
                  LIST2:  in LIST_TYPE)
        return BOOLEAN;
```

Purpose:

This function returns TRUE if the values of the two lists LIST1 and LIST2 are equal according to the following rules; otherwise, it returns FALSE.

Two values of type LIST_TYPE are equal if and only if:

a. both lists are of the same kind (i.e., named, unnamed or empty), and

b. both lists contain the same number of list items, and

c. for each position, the values of list items at this position, as obtained by an EXTRACT operation, are of the same kind and are equal under the equality defined for this kind, and

d. in the case of named lists, for each position, the names of the list items at this position are equal under TOKEN_TYPE equality (i.e., IS_EQUAL).

Parameters:

LIST1, LIST2 are the lists whose equality is to be determined.

Exceptions:

None.

5.4.1.6. Deleting an item from a list

```
procedure DELETE(LIST:      in out LIST_TYPE;
                 POSITION:  in     POSITION_COUNT);

procedure DELETE(LIST:      in out LIST_TYPE;
                 NAMED:     in     NAME_STRING);

procedure DELETE(LIST:      in out LIST_TYPE;
```

```
NAMED:   in   TOKEN_TYPE);
```

Purpose:

This procedure deletes the item specified by POSITION or NAMED from LIST. If this was the last item in the list, the kind of the list changes to EMPTY.

Parameters:

LIST	is the list from which the item will be deleted.
POSITION	is the position within the list that identifies the item to be deleted.
NAMED	is the name of the list item to be deleted.

Exceptions:

USE_ERROR is raised if the parameter NAMED is used with an unnamed list, if the list is empty, if there is no item with the name NAMED or if POSITION has a value larger than the current length of LIST.

5.4.1.7. Determining the kind of list

```
function GET_LIST_KIND(LIST:  in LIST_TYPE)
         return LIST_KIND;
```

Purpose:

This function returns the kind of the referenced list.

Parameters:

LIST	is the list of interest.

Exceptions:

None.

5.4.1.8. Determining the kind of list item

```
function GET_ITEM_KIND(LIST:      in LIST_TYPE;
                       POSITION:  in POSITION_COUNT)
         return ITEM_KIND;

function GET_ITEM_KIND(LIST:  in LIST_TYPE;
                       NAMED: in NAME_STRING)
         return ITEM_KIND;

function GET_ITEM_KIND(LIST:  in LIST_TYPE;
                       NAMED: in TOKEN_TYPE)
         return ITEM_KIND;
```

Purpose:

This function returns the kind of an item in the referenced list.

Parameters:

LIST is the list of interest.

POSITION is the position within the list that identifies the item.

NAMED is the name of the list item.

Exceptions:

USE_ERROR or if POSITION has a value larger than the current length of LIST or if the list is empty.

SEARCH_ERROR
is raised if there is no item with the name NAMED.

5.4.1.9. Inserting a sublist of items into a list

```
procedure SPLICE(LIST:     in out LIST_TYPE;
                 POSITION: in     POSITION_COUNT;
                 SUB_LIST: in     LIST_TEXT);

procedure SPLICE(LIST:     in out LIST_TYPE;
                 POSITION: in     POSITION_COUNT;
                 SUB_LIST: in     LIST_TYPE);
```

Purpose:

This procedure allows a list to be inserted into a list. The items in the list to be inserted will become items in the resulting list. Subsequent modifications to the value of LIST or to the value of SUB_LIST do not affect the other list.

Parameters:

LIST is the list into which a list is to be inserted.

POSITION is the position after which the new items will be inserted.

SUB_LIST is the list to be inserted.

Exceptions:

USE_ERROR is raised if SUB_LIST as LIST_TEXT does not conform to the syntax specified in TABLE XIV. USE_ERROR is also raised if LIST and SUB_LIST are not of the same kind and neither of them is an empty list. USE_ERROR is also raised if LIST and SUB_LIST are both named and contain an item of the same name or if POSITION has a value larger than the current length of the list.

5.4.1.10. Merging two lists

```
procedure MERGE(FRONT:  in     LIST_TYPE;
                BACK:   in     LIST_TYPE;
                RESULT: in out LIST_TYPE);
```

Purpose:

This procedure returns in RESULT a list constructed by concatenating BACK to FRONT. The lists FRONT and BACK must be of the same kind or either FRONT or BACK must be an

empty list. The values of FRONT and BACK are not affected. Subsequent modifications to the values of FRONT or BACK or to the value of the returned RESULT list do not affect the other list.

Parameters:

FRONT — is the first list to be merged.

BACK — is the second list to be merged.

RESULT — is the list produced by the merge; it has the list items of FRONT in its initial sublist and those of BACK as the rest of its items.

Exceptions:

USE_ERROR — is raised if FRONT and BACK are not of the same kind and neither of them is an empty list. USE_ERROR is also raised if FRONT and BACK are both named and contain an item with the same name.

5.4.1.11. Extracting a sublist of items from a list

```
function SET_EXTRACT(LIST:      in LIST_TYPE;
                     POSITION:  in POSITION_COUNT;
                     LENGTH:    in POSITIVE:= POSITIVE'LAST)
         return LIST_TEXT;
```

Purpose:

This function allows a (sub)list to be extracted from a list. The returned value is a copy of the list subset that starts at the item at POSITION and has LENGTH items in it. If there are fewer than LENGTH items in this part of the list, the subset extends to the tail of the list.

Parameters:

LIST — is the list containing the subset to be extracted.

POSITION — is the position within the list that identifies the subset to be extracted.

LENGTH — is the length of the subset.

Exceptions:

USE_ERROR is raised if POSITION has a value larger than the current length of the list.

5.4.1.12. Determining the length of a list

```
function LENGTH(LIST: in LIST_TYPE)
         return COUNT;
```

Purpose:

This function returns a count of the number of items in LIST. If LIST is empty, LENGTH returns zero.

Parameters:

LIST is the list of interest.

Exceptions:

None.

5.4.1.13. Determining the length of a string representing a list or a list item

```
function TEXT_LENGTH(LIST:     in LIST_TYPE)
         return NATURAL;

function TEXT_LENGTH(LIST:     in LIST_TYPE;
                     POSITION: in POSITION_COUNT)
         return POSITIVE;

function TEXT_LENGTH(LIST:  in LIST_TYPE;
                     NAMED: in NAME_STRING)
         return POSITIVE;

function TEXT_LENGTH(LIST:  in LIST_TYPE;
                     NAMED: in TOKEN_TYPE)
         return POSITIVE;
```

Purpose:

This function returns the length of a string representing either a list or the list item identified by POSITION or NAMED in a list.

Parameters:

LIST is the list of interest.

POSITION is the position within the list that identifies the item.

NAMED is the name of the list item.

Exceptions:

USE_ERROR is raised if POSITION has a value larger than the (existing) length of the list or if the parameter NAMED is used with an unnamed list.

SEARCH_ERROR
is raised if there is no item with the name NAMED.

5.4.1.14. Determining the name of a named item

```
procedure ITEM_NAME(LIST:     in LIST_TYPE;
                    POSITION: in POSITION_COUNT;
                    NAME:        out TOKEN_TYPE);
```

Purpose:

This function returns in NAME the token representation of the name of the item in the named list, as specified by POSITION.

Parameters:

LIST	is the list of interest.
POSITION	is the position within the list that identifies the item.
NAME	is the token representation of the name of the item in the named list.

Exceptions:

USE_ERROR is raised if LIST is not a named list. If POSITION has a value larger than the current length of LIST.

5.4.1.15. Determining the position of a named item

```
function POSITION_BY_NAME(LIST:  in LIST_TYPE;
                          NAMED: in NAME_STRING)
         return POSITION_COUNT;

function POSITION_BY_NAME(LIST : in LIST_TYPE;
                          NAMED: in TOKEN_TYPE)
         return POSITION_COUNT;
```

Purpose:

This function returns the position at which an item with the given name NAMED is located in LIST. It may only be used with named lists.

Parameters:

LIST	is the list in which the position of an item is to be found by name.
NAMED	is the name.

Exceptions:

USE_ERROR is raised if LIST is not a named list or if the list is empty.

SEARCH_ERROR
is raised if NAMED is not a name of an item contained in the list.

5.4.1.16. Extracting a list-type item from a list

```
procedure EXTRACT(LIST:       in LIST_TYPE;
                  POSITION:   in POSITION_COUNT;
                  LIST_ITEM:     out LIST_TYPE);

procedure EXTRACT(LIST:       in LIST_TYPE;
                  NAMED:      in NAME_STRING;
                  LIST_ITEM:     out LIST_TYPE);

procedure EXTRACT(LIST:       in LIST_TYPE;
                  NAMED:      in TOKEN_TYPE;
                  LIST_ITEM:    out LIST_TYPE);
```

Purpose:

This function locates a list-type item in a list and returns in LIST_ITEM a copy of it. Subsequent modifications to the values of LIST or to the value returned in LIST_ITEM do not affect the other value.

Parameters:

LIST — is the list containing the item to be extracted.

POSITION — is the position within the list that identifies the item to be extracted.

LIST_ITEM — is the value of the list-type item extracted.

NAMED — is the name of the item to be extracted. It may only be used with named lists.

Exceptions:

USE_ERROR — is raised if the list is empty or if POSITION has a value larger than the current length of the list. USE_ERROR is also raised if NAMED is used with an unnamed list or if the POSITION specification or the name NAMED identifies an item not of list-type kind.

SEARCH_ERROR — is raised if there is not item with the name NAMED.

5.4.1.17. Replacing a list-type item in a list

```
procedure REPLACE(LIST:      in out LIST_TYPE;
                  LIST_ITEM: in     LIST_TYPE;
                  POSITION : in     POSITION_COUNT);

procedure REPLACE(LIST:      in out LIST_TYPE;
                  LIST_ITEM: in     LIST_TYPE;
                  NAMED    : in     NAME_STRING);

procedure REPLACE(LIST:      in out LIST_TYPE;
                  LIST_ITEM: in     LIST_TYPE;
                  NAMED    : in     TOKEN_TYPE);
```

Purpose:

This procedure replaces the value of a list-type item in a list. Subsequent modifications to the values of LIST or of LIST_ITEM does not affect the other value.

Parameters:

LIST — is the list containing the item to be replaced.

LIST_ITEM — is the value of the new item.

POSITION — is the position within the list that identifies the item to be replaced.

NAMED — is the name of the item to be replaced. It may only be used with named lists.

Exceptions:

USE_ERROR — is raised if NAMED is used with an unnamed list, if the POSITION specification or the name NAMED identifies an item not of list-type kind, if the list is empty or or if POSITION has a value larger than the current length of the list.

SEARCH_ERROR
is raised if there is no item with the name NAMED.

5.4.1.18. Inserting a list-type item into a list

```
procedure INSERT(LIST:      in out LIST_TYPE;
                 LIST_ITEM: in     LIST_TYPE;
                 POSITION:  in     COUNT);

procedure INSERT(LIST:      in out LIST_TYPE;
                 LIST_ITEM: in     LIST_TYPE;
                 NAMED    : in     NAME_STRING;
                 POSITION : in     COUNT);

procedure INSERT(LIST:      in out LIST_TYPE;
                 LIST_ITEM: in     LIST_TYPE;
                 NAMED    : in     TOKEN_TYPE;
                 POSITION : in     COUNT);
```

Purpose:

This procedure inserts a list-type item into a list after the list item specified by POSITION. A value of zero in POSITION specifies a position at the head of the list. Subsequent modifications to the values of LIST or of LIST_ITEM do not affect the other value.

Parameters:

LIST is the list into which the item will be inserted.

LIST_ITEM is the value of the item to be inserted.

POSITION is the position in the list after which the item is to be inserted.

NAMED is the name of the new item. It may only be used with named or empty lists.

Exceptions:

USE_ERROR is raised if an attempt is made to insert a named item into an unnamed list or, conversely, an attempt is made to insert an unnamed item into a named list or if LIST is a named list that already contains an item with the name NAMED or if POSITION specifies a value larger than the current length of the list.

5.4.1.19. Identifying a list-type item by value within a list

```
function POSITION_BY_VALUE(LIST:           in LIST_TYPE;
                           VALUE:          in LIST_TYPE;
                           START_POSITION: in POSITION_COUNT
                                           := POSITION_COUNT'FIRST;
                           END_POSITION  : in POSITION_COUNT
                                           := POSITION_COUNT'LAST)
         return POSITION_COUNT;
```

Purpose:

This function returns the position at which the next list-type item of the given value is located. The search begins at the START_POSITION and ends when either an item of value VALUE is found, the last item of the list has been examined, or the item at the END_POSITION has been examined, whichever comes first.

Parameters:

LIST is the list in which the position of an item is to be found.

VALUE is the list-type item value.

START_POSITION
is the position of the first item to be considered in the search.

END_POSITION
is the position beyond which the search will not proceed; the search may terminate prior to reaching END_POSITION should the sought list-type item be found or should the last element of the list be considered.

Exceptions:

USE_ERROR is raised if START_POSITION specifies a value larger than the current length of the list, if the list is empty or if END_POSITION is less than START_POSITION.

SEARCH_ERROR
is raised if the VALUE specified is not found within the region specified by START_POSITION and END_POSITION.

5.4.1.20. Package IDENTIFIER_ITEM

This package provides interfaces for the manipulation of list items whose values are identifiers and of names of list items. Such names and values are represented internally as values of type TOKEN_TYPE.

5.4.1.20.1 Converting an identifier to a token

```
procedure TO_TOKEN(IDENTIFIER: in  NAME_STRING;
                   TOKEN:      out TOKEN_TYPE);
```

Purpose:

This procedure converts the string representation of an identifier into the corresponding internal token representation.

Parameters:

IDENTIFIER is the string to be converted to a token.

TOKEN is the token built and returned according to the value of IDENTIFIER.

Exceptions:

USE_ERROR is raised if the value of the parameter IDENTIFIER does not conform to the syntax of an Ada identifier.

5.4.1.20.2 Converting a token to an identifier

```
function TO_TEXT(LIST_ITEM: in TOKEN_TYPE)
        return NAME_STRING;
```

Purpose:

This function returns the external representation of the value of the LIST_ITEM parameter. The external representation is the string representation defined in Section 5.4. It adheres to the syntax required for NAME_STRING..

Parameters:

LIST_ITEM is the item expressed as a token.

Exceptions:

None.

5.4.1.20.3 Determining the equality of two tokens

```
function IS_EQUAL(TOKEN1:  in TOKEN_TYPE;
                  TOKEN2:  in TOKEN_TYPE);
        return BOOLEAN;
```

Purpose:

This function returns TRUE if the two tokens TOKEN1 and TOKEN2 represent Ada identifiers whose string representation is equal under string comparison, excepting differences in upper and lower case notation; otherwise, it returns FALSE.

Parameters:

TOKEN1, TOKEN2
are the tokens whose equality is to be determined.

Exceptions:

None.

5.4.1.20.4 Extracting an identifier item from a list

```
procedure EXTRACT(LIST:      in LIST_TYPE;
                  POSITION:  in POSITION_COUNT;
                  TOKEN:         out TOKEN_TYPE);

procedure EXTRACT(LIST:   in LIST_TYPE;
                  NAMED:  in NAME_STRING;
                  TOKEN:     out TOKEN_TYPE);

procedure EXTRACT(LIST:   in LIST_TYPE;
                  NAMED:  in TOKEN_TYPE;
                  TOKEN:     out TOKEN_TYPE);
```

Purpose:

This function locates an identifier item in a list and returns in TOKEN a copy of its token.

Parameters:

LIST is the list containing the item to be extracted.

POSITION is the position within the list that identifies the item to be extracted.

TOKEN is the token representation of the identifier item.

NAMED is the name of the item to be extracted. It may only be used with named lists.

Exceptions:

USE_ERROR is raised if NAMED is used with an unnamed list ,if the POSITION specification or the name NAMED identifies an item not of token type if the list is empty or if POSITION has a value larger than the current length of the list.

SEARCH_ERROR is raised if there is no item with the name NAMED.

5.4.1.20.5 Replacing an identifier item in a list

```
procedure REPLACE(LIST:      in out LIST_TYPE;
                  LIST_ITEM: in     TOKEN_TYPE;
                  POSITION:  in     POSITION_COUNT);

procedure REPLACE(LIST:      in out LIST_TYPE;
                  LIST_ITEM: in     TOKEN_TYPE;
                  NAMED    : in     NAME_STRING);

procedure REPLACE(LIST:      in out LIST_TYPE;
                  LIST_ITEM: in     TOKEN_TYPE;
                  NAMED:     in     TOKEN_TYPE);
```

Purpose:

This procedure replaces the value of an identifier item in a list.

Parameters:

LIST is the list containing the item to be replaced.

LIST_ITEM is the new value of the item.

POSITION is the position within the list that identifies the item to be replaced.

NAMED is the name of the item to be replaced. It may only be used with named lists.

Exceptions:

USE_ERROR is raised if NAMED is used with an unnamed list, if the POSITION specification or the name NAMED identifies an item not of identifier kind, if the list is empty, or if POSITION has a value larger than the current length of the list.

SEARCH_ERROR is raised if there is no item with the name NAMED.

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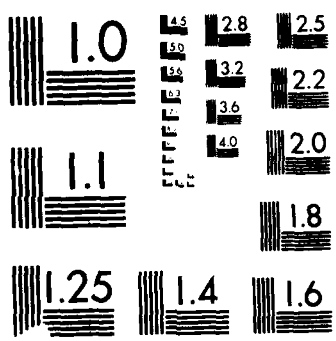
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2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

5.4.1.20.6 Inserting an identifier item into a list

```
procedure INSERT(LIST:      in out LIST_TYPE;
                 LIST_ITEM: in     TOKEN_TYPE;
                 POSITION:  in     COUNT);

procedure INSERT(LIST:      in out LIST_TYPE;
                 LIST_ITEM: in     TOKEN_TYPE;
                 NAMED:     in     NAME_STRING;
                 POSITION:  in     COUNT);

procedure INSERT(LIST:      in out LIST_TYPE;
                 LIST_ITEM: in     TOKEN_TYPE;
                 NAMED    : in     TOKEN_TYPE;
                 POSITION : in     COUNT);
```

Purpose:

This procedure inserts an identifier item into a list after the list item specified by POSITION. A value of zero in POSITION specifies a position at the head of the list.

Parameters:

LIST	is the list into which the item will be inserted.
LIST_ITEM	is the value of the item to be inserted.
POSITION	is the position in the list after which the item is to be inserted.
NAMED	is the name of the new item. It may only be used with named or empty lists.

Exceptions:

USE_ERROR is raised if an attempt is made to insert a named item into an unnamed list or, conversely, an attempt is made to insert an unnamed item into a named list or if LIST is a named list that already contains an item with the name NAMED. USE_ERROR is also raised if POSITION specifies a value larger than the current length of the list.

5.4.1.20.7 Identifying an identifier item by value within a list

```
function POSITION_BY_VALUE(LIST:            in LIST_TYPE;
                           VALUE:           in TOKEN_TYPE;
                           START_POSIITON:  in POSITION_COUNT
                                            := POSITION_COUNT'FIRST;
                           END_POSITION :   in POSITION_COUNT
                                            := POSITION_COUNT'LAST)
        return POSITION_COUNT;
```

Purpose:

This function returns the position at which the next identifier item of the given value is located. The search begins at the START_POSITION and ends when either an item of value VALUE is found, the last item of the list has been examined, or the item at the END_POSITION has been examined, whichever comes first.

Parameters:

LIST	is the list in which the position of an item is to be found by value.

VALUE is the identifier item value (token).

START_POSITION
is the position of the first item to be considered in the search. END_POSITION is the position beyond which the search will not proceed; the search may terminate prior to reaching END_POSITION should the sought identifier item be found or should the last element of the list be considered.

Exceptions:

USE_ERROR is raised if START_POSITION specifies a value larger than the current length of the list, if the list is empty or if END_POSITION is less than START_POSITION.

SEARCH_ERROR
is raised if the VALUE specified is not found within the region specified by START_POSITION and END_POSITION.

5.4.1.21. Generic package INTEGER_ITEM

This is a generic package for manipulating list items which are integers. This package must be instantiated for the appropriate integer type (indicated by NUMBER in the specification).

5.4.1.21.1 Converting an integer item to its canonical external representation

```
function TO_TEXT(LIST_ITEM: in NUMBER)
        return STRING;
```

Purpose:

This function returns the external representation of the value of the LIST_ITEM parameter. The external representation is the string representation defined in Section 5.4.

Parameters:

LIST_ITEM is the integer item whose external representation is to be returned.

Exceptions:

None.

5.4.1.21.2 Extracting an integer item from a list

```
function EXTRACT(LIST:       in LIST_TYPE;
                 POSITION: in POSITION_COUNT)
         return NUMBER;

function EXTRACT(LIST : in LIST_TYPE;
                 NAMED: in NAME_STRING)
         return NUMBER;

function EXTRACT(LIST : in LIST_TYPE;
                 NAMED: in TOKEN_TYPE)
         return NUMBER;
```

Purpose:

This function locates an integer item in a list and returns a copy of its numeric value.

Parameters:

LIST	is the list containing the item to be extracted.
POSITION	is the position within the list that identifies the item to be extracted.
NAMED	is the name of the item to be extracted. It may only be used with named lists.

Exceptions:

USE_ERROR is raised if NAMED is used with an unnamed list, if the POSITION specification or the name NAMED identifies an item not of integer kind, if the list is empty or if POSITION has a value larger than the current length of the list.

SEARCH_ERROR
is raised if there is no item with the name NAMED.

CONSTRAINT_ERROR
is raised if the value to be extracted violates the constraints of the type designated by NUMBER.

5.4.1.21.3 Replacing an integer item in a list

```
procedure REPLACE(LIST:       in out LIST_TYPE;
                  LIST_ITEM:  in     NUMBER;
                  POSITION:   in     POSITION_COUNT);

procedure REPLACE(LIST:       in out LIST_TYPE;
                  LIST_ITEM:  in     NUMBER;
                  NAMED:      in     NAME_STRING);

procedure REPLACE(LIST:       in out LIST_TYPE;
                  LIST_ITEM:  in     NUMBER;
                  NAMED     : in     TOKEN_TYPE);
```

Purpose:

This procedure replaces the value of an integer item in a list.

Parameters:

LIST	is the list containing the item to be replaced.
LIST_ITEM	is the new value of the item.
POSITION	is the position within the list that identifies the item to be replaced.
NAMED	is the name of the item to be replaced. It may only be used with named lists.

Exceptions:

USE_ERROR is raised if NAMED is used with an unnamed list or if the POSITION specification or the name NAMED identifies an item not of integer kind, if the list is empty or if POSITION has a value larger than the current length of the list.

SEARCH_ERROR
is raised if there is no item with the name NAMED.

5.4.1.21.4 Inserting an integer item into a list

```
procedure INSERT(LIST:      in out LIST_TYPE;
                 LIST_ITEM: in     NUMBER;
                 POSITION : in     COUNT);

procedure INSERT(LIST:      in out LIST_TYPE;
                 LIST_ITEM: in     NUMBER;
                 NAMED    : in     NAME_STRING;
                 POSITION : in     COUNT);

procedure INSERT(LIST:      in out LIST_TYPE;
                 LIST_ITEM: in     NUMBER;
                 NAMED:     in     TOKEN_TYPE;
                 POSITION : in     COUNT);
```

Purpose:

This procedure inserts an integer item into a list after the list item specified by POSITION. A value of zero in POSITION specifies a position at the head of the list.

Parameters:

LIST — is the list into which the item will be inserted.

LIST_ITEM — is the value of the item to be inserted.

POSITION — is the position within the list after which the item is to be inserted.

NAMED — is the name of the new item. It may only be used with named or empty lists.

Exceptions:

USE_ERROR is raised if an attempt is made to insert a named item into an unnamed list or, conversely, an attempt is made to insert an unnamed item into a named list or if LIST is a named list that already contains an item with the name NAMED. USE_ERROR is also raised if POSITION specifies a value larger than the current length of the list.

5.4.1.21.5 Identifying an integer item by value within a list

```
function POSITION_BY_VALUE(LIST:           in LIST_TYPE;
                           VALUE:          in NUMBER;
                           START_POSITION: in POSITION_COUNT
                                          := POSITION_COUNT'FIRST;
                           END_POSITION:   in POSITION_COUNT
                                          := POSITION_COUNT'LAST)
         return POSITION_COUNT;
```

Purpose:

This function returns the position at which the next integer item of the given value is located. The search begins at the START_POSITION and ends when either an item of value VALUE is found, the last item of the list has been examined, or the item at the END_POSITION has been examined, whichever comes first.

Parameters:

LIST is the list in which the position of an item is to be found.

VALUE is the integer item value.

START_POSITION
is the position of the first item to be considered in the search. END_POSITION is the position beyond which the search will not proceed; the search may terminate prior to reaching END_POSITION should the sought integer item be found or should the last element of the list be considered.

Exceptions:

USE_ERROR is raised if START_POSITION specifies a value larger than the current length of the list, if the list is empty or if END_POSITION is less than START_POSITION.

SEARCH_ERROR
is raised or the VALUE specified is not found within the region specified by START_POSITION and END_POSITION.

5.4.1.22. Generic package FLOAT_ITEM

This is a generic package for manipulating list items which are floating point numbers. This package must be instantiated for the appropriate type (indicated by NUMBER in the specification).

5.4.1.22.1 Converting a floating point item to its canonical external representation

```
function TO_TEXT(LIST_ITEM: in NUMBER
         return STRING;
```

Purpose:

This function returns the external representation of the value of the LIST_ITEM parameter. The external representation is the string representation defined in Section 5.4.

Parameters:

LIST_ITEM is the floating point item whose external representation is to be returned.

Exceptions:

None.

5.4.1.22.2 Extracting a floating point item from a list

```
function EXTRACT(LIST:      in  LIST_TYPE;
                 POSITION:  in  POSITION_COUNT)
         return NUMBER;

function EXTRACT(LIST:  in  LIST_TYPE;
                 NAMED: in  NAME_STRING)
         return NUMBER;

function EXTRACT(LIST:  in  LIST_TYPE;
                 NAMED: in  TOKEN_TYPE)
```

```
return NUMBER;
```

Purpose:

This function locates a floating point item in a list and returns a copy of its numeric value.

Parameters:

LIST — is the list containing the item to be extracted.

POSITION — is the position within the list that identifies the item to be extracted.

NAMED — is the name of the item to be extracted. It may only be used with named lists.

Exceptions:

USE_ERROR is raised if NAMED is used with an unnamed list, if the POSITION specification or the name NAMED identifies an item not of floating point kind, if the list is empty or if POSITION has a value larger than the current length of the list.

SEARCH_ERROR
is raised if there is no item with the name NAMED.

CONSTRAINT_ERROR
is raised if the value to be extracted violates the constraints of the type designated by NUMBER.

5.4.1.22.3 Replacing a floating point item into a list

```
procedure REPLACE(LIST:       in out LIST_TYPE;
                  LIST_ITEM:  in     NUMBER;
                  POSITION:   in     POSITION_COUNT);

procedure REPLACE(LIST:       in out LIST_TYPE;
                  LIST_ITEM:  in     NUMBER;
                  NAMED:      in     NAME_STRING);

procedure REPLACE(LIST:       in out LIST_TYPE;
                  LIST_ITEM:  in     NUMBER;
                  NAMED:      in     TOKEN_TYPE);
```

Purpose:

This procedure replaces the value of a floating point item in a list.

Parameters:

LIST — is the list containing the item to be replaced.

LIST_ITEM — is the new value of the item.

POSITION — is the position within the list that identifies the item to be replaced.

NAMED — is the name of the item to be replaced. It may only be used with named lists.

Exceptions:

USE_ERROR is raised if NAMED is used with an unnamed list, if the POSITION specification or

the name NAMED identifies an item not of floating point kind, if the list is empty or if POSITION has a value larger than the current length of the list.

SEARCH_ERROR
is raised if there is no item with the name NAMED.

5.4.1.22.4 Inserting a floating point item into a list

```
procedure INSERT(LIST:      in out LIST_TYPE;
                 LIST_ITEM: in     NUMBER;
                 POSITION:  in     COUNT);

procedure INSERT(LIST:      in out LIST_TYPE;
                 LIST_ITEM: in     NUMBER;
                 NAMED:     in     NAME_STRING;
                 POSITION:  in     COUNT);

procedure INSERT(LIST:      in out LIST_TYPE;
                 LIST_ITEM: in     NUMBER;
                 NAMED:     in     TOKEN_TYPE;
                 POSITION:  in     COUNT);
```

Purpose:

This procedure inserts a floating point item into a list after the list item specified by POSITION. A value of zero in POSITION specifies a position at the head of the list.

Parameters:

LIST is the list into which the item will be inserted.

LIST_ITEM is the value of the item to be inserted.

POSITION is the position in the list after which the item is to be inserted.

NAMED is the name of the new item. It may only be used with named or empty lists.

Exceptions:

USE_ERROR is raised if an attempt is made to insert a named item into an unnamed list or, conversely, an attempt is made to insert an unnamed item into a named list or if LIST is a named list that already contains an item with the name NAMED. USE_ERROR is also raised if POSITION specifies a value larger than the current length of the list.

5.4.1.22.5 Identifying a floating point item by value within a list

```
function POSITION_BY_VALUE(LIST:           in LIST_TYPE;
                           VALUE           in NUMBER
                           START_POSITION: in POSITION_COUNT
                                           := POSITION_COUNT'FIRST;
                           END_POSITION:   in POSITION_COUNT
                                           := POSITION_COUNT'LAST)
        return POSITION_COUNT;
```

Purpose:

This function returns the position at which the next floating point item of the given value is

located. The search begins at the START_POSITION and ends when either an item of value VALUE is found the last item of the list has been examined, or the item at the END_POSITION has been examined, whichever comes first.

Parameters:

LIST is the list in which the position of an item is to be found.

VALUE is the floating point item value.

START_POSITION
is the position of the first item to be considered in the search.

END_POSITION
is the position beyond which the search will not proceed; the search may terminate prior to reaching END_POSITION should the sought floating point item be found or should the last element of the list be considered.

Exceptions:

USE_ERROR is raised if START_POSITION specifies a value larger than the current length of the list, or if END_POSITION is less than START_POSITION.

SEARCH_ERROR
is raised the VALUE specified is not found within the region specified by START_POSITION and END_POSITION.

5.4.1.23. Package STRING_ITEM

This is a package for manipulating list items which are strings. The external representation of the value of a string item is the string returned by an EXTRACT operation applied to the string item.

5.4.1.23.1 Extracting a string item from a list

```
function EXTRACT(LIST:     in LIST_TYPE;
                 POSITION: in POSITION_COUNT)
         return  STRING;

function EXTRACT(LIST:     in LIST_TYPE;
                 NAMED:    in NAME_STRING)
         return  STRING;

function EXTRACT(LIST:     in LIST_TYPE;
                 NAMED:    in TOKEN_TYPE)
         return  STRING;
```

Purpose:

This function locates a string item in a list and returns a copy of it.

Parameters:

LIST is the list containing the item to be extracted.

POSITION is the position within the list that identifies the item to be extracted.

NAMED is the name of the item to be extracted. It may only be used with named lists.

Exceptions:

USE_ERROR is raised if NAMED is used with an unnamed list, if the POSITION specification or the name NAMED identifies an item not of string kind, if the list is empty or if POSITION has a value larger than the current length of the list.

SEARCH_ERROR
is raised if there is no item with the name NAMED.

5.4.1.23.2 Replacing a string item in a list

```
procedure REPLACE(LIST:       in out LIST_TYPE;
                  LIST_ITEM:  in     STRING;
                  POSITION:   in     POSITION_COUNT);

procedure REPLACE(LIST:       in out LIST_TYPE;
                  LIST_ITEM:  in     STRING;
                  NAMED:      in     NAME_STRING);

procedure REPLACE(LIST:       in out LIST_TYPE;
                  LIST_ITEM:  in     STRING;
                  NAMED     : in     TOKEN_TYPE);
```

Purpose:

This procedure replaces the value of a string item in a list.

Parameters:

LIST is the list containing the item to be replaced.

LIST_ITEM is the new value of the item.

POSITION is the position within the list that identifies the item to be replaced.

NAMED is the name of the item to be replaced. It may only be used with named lists.

Exceptions:

USE_ERROR is raised if NAMED is used with an unnamed list or if the POSITION specification or the name NAMED identifies an item not of string kind, if the list is empty or if POSITION has a value larger than the current length of the list.

SEARCH_ERROR
is raised if there is no item with the name NAMED.

5.4.1.23.3 Inserting a string item into a list

```
procedure INSERT(LIST:       in out LIST_TYPE;
                 LIST_ITEM:  in     STRING;
                 POSITION:   in     COUNT);

procedure INSERT(LIST:       in out LIST_TYPE;
```

```
                 LIST_ITEM: in      STRING;
                 NAMED:     in      NAME_STRING;
                 POSITION:  in      COUNT);

procedure INSERT(LIST:      in out LIST_TYPE;
                 LIST_ITEM: in      STRING;
                 NAMED:     in      TOKEN_TYPE;
                 POSITION : in      COUNT);
```

Purpose:

This procedure inserts a string item into a list after the list item specified by POSITION. A value of zero in POSITION specifies a position at the head of the list.

Parameters:

LIST — is the list into which the item will be inserted.

LIST_ITEM — is the value of the item to be inserted.

POSITION — is the position in the list after which the item is to be inserted.

NAMED — is the name of the new item. It may only be used with named or empty lists.

Exceptions:

USE_ERROR is raised if an attempt is made to insert a named item into an unnamed list or, conversely, an attempt is made to insert an unnamed item into a named list or if LIST is a named list that already contains an item with the name NAMED. USE_ERROR is also raised if POSITION specifies a value larger than the current length of the list.

5.4.1.23.4 Identifying a string item by value within a list

```
function POSITION_BY_VALUE(LIST:           in LIST_TYPE;
                           VALUE:          in STRING;
                           START_POSITION: in POSITION_COUNT
                                              :=POSITION_COUNT'FIRST;
                           END_POSITION  : in POSITION_COUNT
                                              :=POSITION_COUNT'LAST)
        return POSITION_COUNT;
```

Purpose:

This function returns the position at which the next string item of the given value is located. The search begins at the START_POSITION and ends when either an item of value VALUE is found, the last item of the list has been examined, or the item at the END_POSITION has been examined, whichever comes first.

Parameters:

LIST — is the list in which the position of an item is to be found by value.

VALUE — is the string item value.

START_POSITION
is the position of the first item to be considered in the search.

END_POSITION
is the position beyond which the search will not proceed; the search may terminate prior to reaching END_POSITION should the sought string item be found or should the last element of the list be considered.

Exceptions:

USE_ERROR is raised if START_POSITION specifies a value larger than the current length of the list, if the list is empty or if END_POSITION is less than START_POSITION.

SEARCH_ERROR
is raised if the VALUE specified is not found within the region specified by START_POSITION and END_POSITION.

Exceptions:

USE_ERROR is raised if POSITION has a value larger than the current length of the list.

6. NOTES

6.1. Keywords

The following list represents the keywords applicable to this standard. These keywords may be used to categorize the concepts presented within this standard and assist in automatic retrieval of appropriate data used in automated document retrieval systems.

```
Ada
APSE
CAIS
Common APSE Interface Set
computer file system
KAPSE
high level languages
interfaces
interoperability
operating system
portability
programming support environment
software engineering envirorment
transportability
virtual operating system
```

Appendix A
PREDEFINED RELATIONS, ATTRIBUTES AND ATTRIBUTE VALUES

Predefined Relations:

ACCESS: designates a secondary relationship from an object node to a node representing a role; the access rights that can be granted to adopters of the role are given in the GRANT attribute of this relationship.

ADOPTED_ROLE:
designates a secondary relationship from a subject (process) node to a node representing a role; indicates that the process has adopted the role represented by the node.

ALLOW_ACCESS:
designates a secondary relationship from a process node to a node representing a role; indicates that the process can create relationships of the predefined relation ACCESS from an object to this node representing the role.

COUPLE: designates a secondary relationship from a node representing a queue file to the node representing that file's coupled file; indicates that the queue file and the other file are coupled; for copy queue files, this means the contents of the file are the initial contents of the queue file; for mimic queue files, this means that the contents of the file are the initial contents of the queue file and subsequent writes to the queue file are appended to the other file as well.

CURRENT_ERROR:
designates a secondary relationship from a process node to a file node representing the file to which error messages are to be written.

CURRENT_INPUT:
designates a secondary relationship from a process node to a file node representing the file which is currently the source of process inputs.

CURRENT_JOB:
designates a secondary relationship from a process node to the root process node of the tree which contains the process node.

CURRENT_NODE:
designates a secondary relationship from a process node to the node representing the current focus of attention or context for the process' activities.

CURRENT_OUTPUT:
designates a secondary relationship from a process node to a file node representing the file to which outputs are currently being directed.

CURRENT_USER:
designates a secondary relationship from a process node to a top-level node representing the user on whose behalf the process was initiated.

DEVICE: designates a secondary relationship from a process node to a top-level node

representing a device to which the process has access. Also designates a primary relationship from the system-level node to a node representing a device.

DOT: designates the default relation name to be used when none is provided. Special rules apply for pathname abbreviations in the presence of path elements whose relation name is DOT. No other semantics are associated with DOT.

JOB: designates a primary relationship from the top-level node of a user to the root process node of a job.

PARENT: designates the secondary relationship from a given node to the node which is the source of the unique primary relationship pointing to the given node.

PERMANENT_MEMBER:
designates a primary relationship from a node representing a group to the node representing a permanent member of the group.

POTENTIAL_MEMBER:
designates a secondary relationship from a node representing a group to the node representing a potential member of the group.

STANDARD_ERROR:
designates the secondary relationship from a process node to a file node representing the standard device for error messages for the whole job.

STANDARD_INPUT:
designates the secondary relationship from a process node to a file representing the standard input device for the whole job.

STANDARD_OUTPUT:
designates the secondary relationship from a process node to a file node representing the standard output device for the whole job.

USER: designates a secondary relationship from a process node to a user's top-level node. Also designates a primary relationship from the system-level node to a top-level node representing a user.

Predefined Attributes:

ACCESS_METHOD:
applies to file nodes; designates the kind of access which can be used on the node's contents; possible values are SEQUENTIAL, DIRECT and TEXT.

CURRENT_STATUS:
applies to process nodes; designates the current status of the node's contents; possible values are READY, SUSPENDED, ABORTED and TERMINATED.

FILE_KIND: applies to file nodes; designates the kind of file that is the node's contents; possible values are SECONDARY_STORAGE, QUEUE, TERMINAL and MAGNETIC_TAPE.

FINISH_TIME:
applies to process nodes; designates the implementation-defined time at which the process terminated or aborted.

GRANT: applies to relationships of the predefined relation ACCESS; designates the access rights which can be granted via the access relationship; values are lists of relevant grant items as specified in TABLE II.

HANDLES_OPEN:
applies to process nodes; designates the number of node handles the node's process currently has opened.

HIGHEST_CLASSIFICATION:
applies to file nodes; designates the highest allowable object classification label that may be assigned to the node; values are implementation-defined.

IO_UNITS: applies to process nodes; designates the number of GET and PUT operations that have been performed by the node's process.

KIND: applies to all relationships; designates the kind of the target node; possible values are STRUCTURAL, PROCESS and FILE.

LOWEST_CLASSIFICATION:
applies to file nodes; designates the lowest allowable object classification label that may be assigned to the node; values are implementation-defined.

MACHINE_TIME:
applies to process nodes; designates the length of time the process was active on the logical processor, if the process has terminated or aborted, or zero, if the process has not terminated or aborted.

OBJECT_CLASSIFICATION:
applies to all nodes; designates the node's classification as an object; values are implementation-defined.

PARAMETERS:
applies to process nodes; designates the parameters with which the process was initiated.

QUEUE_KIND:
applies to file nodes with a FILE_KIND attribute value of QUEUE; designates the kind of queue file; possible values are SOLO, MIMIC and COPY.

RESULTS: applies to process nodes; designates the intermediate results of the process; values are user-defined.

START_TIME:
applies to process nodes; designates the implementation-defined time of activation of the process.

SUBJECT_CLASSIFICATION:

applies to process nodes; designates the classification of the node's process as a subject; values ar implementation-defined.

TERMINAL_KIND:
applies to file nodes with a FILE_KIND attribute value of TERMINAL; designates the kind of terminal which is represented by the node's contents; possible values are SCROLL, PAGE and FORM.

Predefined Attribute Values:

ABORTED
APPEND
APPEND_ATTRIBUTES
APPEND_CONTENTS
APPEND_RELATIONSHIPS
CONTROL
COPY
DIRECT
EXECUTE
EXISTENCE
FILE
FORM
MAGNETIC_TAPE
MIMIC
PAGE
PROCESS
QUEUE
READ
READ_ATTRIBUTES
READ_CONTENTS
READ_RELATIONSHIPS
READY
SCROLL
SECONDARY_STORAGE
SEQUENTIAL
SOLO
STRUCTURAL
SUSPENDED
TERMINAL
TERMINATED
TEXT
WRITE
WRITE_ATTRIBUTES
WRITE_CONTENTS
WRITE_RELATIONSHIPS

Appendix B
CAIS Specification

This appendix contains a set of Ada package specifications of the CAIS interfaces which compiles correctly. It brings together the interfaces found in Section 5 using the Nested Generic Subpackages Implementation approach. Although the interfaces are not necessarily shown here in the order in which they are discussed in the text, this appendix provides a reference listing of the CAIS as well as an illustration of the generics approach.

```
with CALENDAR;
use CALENDAR;
package CAIS is
    package NODE_DEFINITIONS is

        type NODE_TYPE is limited private;
        type NODE_KIND is (FILE, STRUCTURAL, PROCESS);
        type INTENT_SPECIFICATION is
             (EXISTENCE,
              READ,
              WRITE,
              READ_ATTRIBUTES,
              WRITE_ATTRIBUTES,
              APPEND_ATTRIBUTES,
              READ_RELATIONSHIPS,
              WRITE_RELATIONSHIPS,
              APPEND_RELATIONSHIPS,
              READ_CONTENTS,
              WRITE_CONTENTS,
              APPEND_CONTENTS,
              CONTROL,
              EXECUTE,
              EXCLUSIVE_READ,
              EXCLUSIVE_WRITE,
              EXCLUSIVE_READ_ATTRIBUTES,
              EXCLUSIVE_WRITE_ATTRIBUTES,
              EXCLUSIVE_APPEND_ATTRIBUTES,
              EXCLUSIVE_READ_RELATIONSHIPS,
              EXCLUSIVE_WRITE_RELATIONSHIPS,
              EXCLUSIVE_APPEND_RELATIONSHIPS,
              EXCLUSIVE_READ_CONTENTS,
              EXCLUSIVE_WRITE_CONTENTS,
              EXCLUSIVE_APPEND_CONTENTS,
              EXCLUSIVE_CONTROL);
        type INTENTION is array (POSITIVE range <>)
                                     of INTENT_SPECIFICATION;

        subtype NAME_STRING      is STRING;
        subtype RELATIONSHIP_KEY is STRING;
        subtype RELATION_NAME    is STRING;
        subtype FORM_STRING      is STRING;

        CURRENT_USER     : constant NAME_STRING :=
                           "'CURRENT_USER";
        CURRENT_NODE     : constant NAME_STRING :=
                           "'CURRENT_NODE";
        CURRENT_PROCESS  : constant NAME_STRING := ":";
        LATEST_KEY       : constant RELATIONSHIP_KEY := "#";
        DEFAULT_RELATION : constant RELATION_NAME := "DOT";
        NO_DELAY         : constant DURATION := DURATION'FIRST;

        STATUS_ERROR       : exception;
        NAME_ERROR         : exception;
```

```
    USE_ERROR           : exception;
    LOCK_ERROR          : exception;
    ACCESS_VIOLATION    : exception;
    INTENT_VIOLATION    : exception;
    SECURITY_VIOLATION  : exception;

private
    type NODE_TYPE is
        (IMPLEMENTATION_DEFINED);
      -- should be defined by implementor
end NODE_DEFINITIONS;

package LIST_UTILITIES is
    use NODE_DEFINITIONS;
    type LIST_TYPE  is private;
    type TOKEN_TYPE is private;
    type LIST_KIND is (UNNAMED, NAMED, EMPTY);
    type ITEM_KIND is
        (LIST_ITEM,        STRING_ITEM,
         INTEGER_ITEM,     FLOAT_ITEM,       IDENTIFIER_ITEM);
    type COUNT is range 0 .. INTEGER'LAST;

    subtype LIST_TEXT is STRING;

    subtype POSITION_COUNT is COUNT range COUNT'FIRST + 1 ..
                                         COUNT'LAST;

    procedure COPY(TO_LIST: LIST_TYPE;
                   FROM_LIST: LIST_TYPE);

    function  TO_LIST(LIST_STRING: STRING)
            return LIST_TYPE;
    function  TO_TEXT(LIST_ITEM : LIST_TYPE)
            return LIST_TEXT;
    function IS_EQUAL(LIST1: LIST_TYPE;
                      LIST2: LIST_TYPE)
            return BOOLEAN;

    function  EXTRACT(LIST     : LIST_TYPE;
                      POSITION : POSITION_COUNT)
            return LIST_TYPE;
    function  EXTRACT(LIST  : LIST_TYPE;
                      NAMED : NAME_STRING)
            return LIST_TYPE;
    function  EXTRACT(LIST  : LIST_TYPE;
                      NAMED : TOKEN_TYPE)
            return LIST_TYPE;
    procedure REPLACE(LIST      : in out LIST_TYPE;
                      LIST_ITEM : LIST_TYPE;
                      POSITION  : POSITION_COUNT);
    procedure REPLACE(LIST      : in out LIST_TYPE;
                      LIST_ITEM : LIST_TYPE;
                      NAMED     : NAME_STRING);
    procedure REPLACE(LIST      : in out LIST_TYPE;
                      LIST_ITEM : LIST_TYPE;
                      NAMED     : TOKEN_TYPE);
    procedure INSERT(LIST      : in out LIST_TYPE;
                     LIST_ITEM : LIST_TYPE;
                     POSITION  : COUNT);
    procedure INSERT(LIST      : in out LIST_TYPE;
                     LIST_ITEM : LIST_TYPE;
                     NAMED     : NAME_STRING;
                     POSITION  : COUNT);
    procedure INSERT(LIST      : in out LIST_TYPE;
```

```
                    LIST_ITEM : LIST_TYPE;
                    NAMED     : TOKEN_TYPE;
                    POSITION  : COUNT);
function  POSITION_BY_VALUE(LIST  : LIST_TYPE;
                           VALUE : LIST_TYPE
                           START_POSITION: POSITION_COUNT
                             := POSITION_COUNT'FIRST;
                           END_POSITION: POSITION_COUNT
                             := POSITION_COUNT'LAST)
         return POSITION_COUNT;


function  SET_EXTRACT
            (LIST     : LIST_TYPE;
             POSITION : POSITION_COUNT;
             LENGTH   : POSITIVE := POSITIVE'LAST)
                   return LIST_TEXT;

procedure SPLICE(LIST     : in out LIST_TYPE;
                 POSITION : POSITION_COUNT;
                 SUB_LIST : LIST_TEXT);
procedure SPLICE(LIST     : in out LIST_TYPE;
                 POSITION : POSITION_COUNT;
                 SUB_LIST : LIST_TYPE);

procedure DELETE(LIST     : in out LIST_TYPE;
                 POSITION : POSITION_COUNT);
procedure DELETE(LIST  : in out LIST_TYPE;
                 NAMED : NAME_STRING);
procedure DELETE(LIST: inout LIST_TYPE;
                 NAMED: TOKEN_TYPE);
function GET_LIST_KIND(LIST: LIST_TYPE)
        return LIST_KIND;

function GET_ITEM_KIND(LIST : LIST_TYPE)
        return LIST_KIND;
function GET_ITEM_KIND(LIST     : LIST_TYPE;
                       POSITION : POSITION_COUNT)
        return ITEM_KIND;
function GET_ITEM_KIND(LIST  : LIST_TYPE;
                       NAMED : NAME_STRING)
        return ITEM_KIND;
procedure MERGE(FRONT  : LIST_TYPE;
                BACK   : LIST_TYPE;
                RESULT : in out LIST_TYPE);
function  LENGTH(LIST : LIST_TYPE) return COUNT;
procedure ITEM_NAME(LIST       : LIST_TYPE;
                    POSITION   : POSITION_COUNT;
                    NAME       : out TOKEN_TYPE;
                    NAME_RANGE : out POSITIVE);
function  ITEM_NAME(LIST     : LIST_TYPE.
                   POSITION : POSITION_COUNT)
        return NAME_STRING;
function POSITION_BY_NAME(LIST: LIST_TYPE;
                         NAMED: NAME_STRING)
        return POSITION_COUNT;
function POSITION_BY_NAME  (LIST  : LIST_TYPE;
                    NAMED     : TOKEN_TYPE)
                   return POSITION_TYPE;

function TEXT_LENGTH       (LIST : LIST_TYPE)
                   return NATURAL;
function TEXT_LENGTH       (LIST : LIST_TYPE;
                  POSITION   : POSITION_COUNT)
                   return POSITIVE;
```

```
function TEXT_LENGTH       (LIST  : LIST_TYPE;
                       NAMED      : NAME_STRING)
                        return POSITIVE;
function TEXT_LENGTH       (LIST  : LIST_TYPE;
                       NAMED      : TOKEN_TYPE)
                        return POSITIVE;

package IDENTIFIER_ITEM is
    procedure TO_TOKEN(IDENTIFIER: in NAME_STRING;
                       TOKEN:          out TOKEN_TYPE);

    function TO_TEXT(LIST_ITEM: in TOKEN_TYPE)
             return NAME_STRING;

    function IS_EQUAL(TOKEN1: in TOKEN_TYPE;
                      TOKEN2: in TOKEN_TYPE);
             return BOOLEAN;


    procedure EXTRACT(LIST: in LIST_TYPE;
                      POSITION: in POSITION_COUNT;
                      TOKEN:     out TOKEN_TYPE);
    procedure EXTRACT(LIST: in LIST_TYPE;
                      NAMED: in NAME_STRING;
                      TOKEN:     out TOKEN_TYPE);

    procedure EXTRACT(LIST: in LIST_TYPE;
                      NAMED: in TOKEN_TYPE;
                      TOKEN:     out TOKEN_TYPE);

    procedure REPLACE(LIST: in out LIST_TYPE;
                      LIST_ITEM: in TOKEN_TYPE;
                      POSITION: in POSITION_COUNT);

    procedure REPLACE(LIST: in out LIST_TYPE;
                      LIST_ITEM: in TOKEN_TYPE;
                      NAMED: in TOKEN_TYPE);

    procedure REPLACE(LIST: in out LIST_TYPE;
                      LIST_ITEM: in TOKEN_TYPE;
                      NAMED: in TOKEN_TYPE);

    procedure INSERT(LIST: in out LIST_TYPE;
                     LIST_ITEM: in TOKEN_TYPE;
                     POSITION: in COUNT);

    procedure INSERT(LIST: in out LIST_TYPE;
                     LIST_ITEM: in TOKEN_TYPE;
                     NAMED: in NAME_STRING;
                     POSITION: in COUNT);

    procedure INSERT(LIST: in out LIST_TYPE;
                     LIST_ITEM: in TOKEN_TYPE;
                     NAMED: in TOKEN_TYPE;
                     POSITION: in COUNT);

    function POSITION_BY_VALUE(LIST: in LIST_TYPE;
                               VALUE: in TOKEN_TYPE;
                               START_POSITION: in
                                   POSITION_COUNT :=
                                   POSITION_COUNT'FIRST'
                               END_POSITION: in
                                   POSITION_COUNT :=
                                   POSITION_COUNT'LAST)
```

```
                return POSITION_COUNT;

        end IDENTIFIER_ITEM;
        generic
            type NUMBER is range <>;
        package INTEGER_ITEM is
            function  EXTRACT  (LIST     : LIST_TYPE;
                                POSITION : POSITION_COUNT)
                                 return NUMBER;
            function  EXTRACT  (LIST  : LIST_TYPE;
                                NAMED : NAME_STRING)
                                 return NUMBER;
            function  EXTRACT  (LIST  : LIST_TYPE;
                                NAMED : TOKEN_TYPE)
                                 return NUMBER;
            procedure REPLACE   (LIST      : in out LIST_TYPE;
                                LIST_ITEM : NUMBER;
                                POSITION  : POSITION_COUNT);
            procedure REPLACE   (LIST      : in out LIST_TYPE;
                                LIST_ITEM : NUMBER;
                                NAMED     : NAME_STRING);
            procedure REPLACE   (LIST      : in out LIST_TYPE;
                                LIST_ITEM : NUMBER;
                                NAMED     : TOKEN_TYPE);
            procedure INSERT    (LIST      : in out LIST_TYPE;
                                LIST_ITEM : NUMBER;
                                POSITION  : COUNT);
            procedure INSERT    (LIST      : in out LIST_TYPE;
                                LIST_ITEM : NUMBER;
                                NAMED     : NAME_STRING
                                POSITION  : COUNT);
            procedure INSERT    (LIST      : in out LIST_TYPE;
                                LIST_ITEM : NUMBER;
                                NAMED     : TOKEN_TYPE;
                                POSITION  : COUNT);
            function  POSITION_BY_VALUE (LIST  : LIST_TYPE;
                                          VALUE : NUMBER;
                                          START_POSITION:
                                POSITION_COUNT:= POSITION_COUNT'FIRST;
                                          END_POSITION: POSITION_COUNT
                                := POSITION_COUNT'LAST)
                return POSITION_COUNT;
        end INTEGER_ITEM;
        generic
            type NUMBER is digits <>;
        package FLOAT_ITEM is
            function TO_TEXT(LIST_ITEM: NUMBER)
                return STRING;

            function  EXTRACT  (LIST     : LIST_TYPE;
                                POSITION : POSITION_COUNT)
                                 return NUMBER;
            function  EXTRACT  (LIST  : LIST_TYPE;
                                NAMED : NAME_STRING)
                                 return NUMBER;
            function  EXTRACT  (LIST  : LIST_TYPE;
                                NAMED : TOKEN_TYPE)
                                 return NUMBER;
            procedure REPLACE   (LIST      : in out LIST_TYPE;
                                LIST_ITEM : NUMBER;
                                POSITION  : POSITION_COUNT);
            procedure REPLACE   (LIST      : in out LIST_TYPE;
                                LIST_ITEM : NUMBER;
                                NAMED     : NAME_STRING);
```

```
        procedure REPLACE  (LIST       : in out LIST_TYPE;
                           LIST_ITEM : NUMBER;
                           NAMED     : TOKEN_TYPE);
        procedure INSERT   (LIST       : in out LIST_TYPE;
                           LIST_ITEM : NUMBER;
                           POSITION  : COUNT);
        procedure INSERT   (LIST       : in out LIST_TYPE;
                           LIST_ITEM : NUMBER;
                           NAMED: NAME_STRING;
                           POSITION  : COUNT);
        procedure INSERT   (LIST       : in out LIST_TYPE;
                           LIST_ITEM : NUMBER;
                           NAMED     : NAME_STRING;
                           POSITION  : COUNT);
        function  POSITION_BY_VALUE(LIST   : LIST_TYPE;
                                   VALUE  : NUMBER;
                                   START_POSITION:
                           POSITION_COUNT:= POSITION_COUNT'FIRST;
                                   END_POSITION:
                           POSITION_COUNT:= POSITION_COUNT'LAST)
                 return POSITION_COUNT;
    end FLOAT_ITEM;
    package STRING_ITEM is
        function  EXTRACT  (LIST     : LIST_TYPE;
                           POSITION : POSITION_COUNT)
                            return STRING;
        function  EXTRACT  (LIST   : LIST_TYPE;
                           NAMED : NAME_STRING)
                            return STRING;
        function  EXTRACT  (LIST   : LIST_TYPE;
                           NAMED : TOKEN_TYPE)
                            return STRING;
        procedure REPLACE  (LIST       : in out LIST_TYPE;
                           LIST_ITEM : STRING;
                           POSITION  : POSITION_COUNT);
        procedure REPLACE  (LIST       : in out LIST_TYPE;
                           LIST_ITEM : STRING;
                           NAMED     : NAME_STRING);
        procedure REPLACE  (LIST       : in out LIST_TYPE;
                           LIST_ITEM : STRING;
                           NAMED     : TOKEN_TYPE);
        procedure INSERT   (LIST       : in out LIST_TYPE;
                           LIST_ITEM : STRING;
                           POSITION  : COUNT);
        procedure INSERT   (LIST       : in out LIST_TYPE;
                           LIST_ITEM : STRING;
                           NAMED     : NAME_STRING;
                           POSITION  : COUNT);
        procedure INSERT   (LIST       : in out LIST_TYPE;
                           LIST_ITEM : STRING;
                           NAMED     : TOKEN_TYPE;
                           POSITION  : COUNT);
        function  POSITION_BY_VALUE     (LIST   : LIST_TYPE;
                           VALUE : STRING
                           START_POSITION: POSITION_COUNT
                                       := POSITION_COUNT'FIRST;
                           END_POSITION: POSITION_COUNT
                                       := POSITION_COUNT'LAST)
                 return POSITION_COUNT;
    end STRING_ITEM;

private
    type TOKEN_TYPE is (IMPLEMENTATION_DEFINED);
    -- should be defined by implementor
    type LIST_TYPE is (IMPLEMENTATION_DEFINED);
```

```
        -- should be defined by implementor

    end LIST_UTILITIES;
    package NODE_MANAGEMENT is
        use NODE_DEFINITIONS;

        type NODE_ITERATOR is limited private;
        subtype RELATIONSHIP_KEY_PATTERN is RELATIONSHIP_KEY;
        subtype RELATION_NAME_PATTERN    is RELATION_NAME;

        procedure OPEN
                    (NODE       : in out NODE_TYPE;
                     NAME       : NAME_STRING;
                     INTENT     : INTENTION := (1 => READ);
                     TIME_LIMIT : DURATION := NO_DELAY);
        procedure OPEN
                    (NODE       : in out NODE_TYPE;
                     BASE       : NODE_TYPE;
                     KEY        : RELATIONSHIP_KEY;
                     RELATION   : RELATION_NAME :=
                                  DEFAULT_RELATION;
                     INTENT     : INTENTION := (1 => READ);
                     TIME_LIMIT : DURATION := NO_DELAY);
        procedure CLOSE            (NODE : in out NODE_TYPE);
        procedure CHANGE_INTENT
                    (NODE       : in out NODE_TYPE;
                     INTENT     : INTENTION;
                     TIME_LIMIT : DURATION := NO_DELAY);
        function  IS_OPEN          (NODE : NODE_TYPE)
                          return BOOLEAN);
        function INTENT_OF        (NODE : NODE_TYPE)
                                   return INTENTION;
        function  GET_ITEM_KIND (NODE : NODE_TYPE)
                                   return NODE_KIND;
        function  PRIMARY_NAME     (NODE : NODE_TYPE)
                                   return NAME_STRING;
        function  PRIMARY_KEY      (NODE : NODE_TYPE)
                                   return RELATIONSHIP_KEY;
        function  PRIMARY_RELATION (NODE : NODE_TYPE)
                                   return RELATION_NAME;
        function  PATH_KEY         (NODE : NODE_TYPE)
                                   return RELATIONSHIP_KEY;
        function  PATH_RELATION    (NODE : NODE_TYPE)
                                   return RELATION_NAME;
        function  BASE_PATH        (NAME : NAME_STRING)
                                   return NAME_STRING;
        function  LAST_RELATION    (NAME : NAME_STRING)
                                   return RELATION_NAME;
        function  LAST_KEY         (NAME : NAME_STRING)
                                   return RELATIONSHIP_KEY;
        function  IS_OBTAINABLE    (NODE : NODE_TYPE)
                                   return BOOLEAN;
        function  IS_OBTAINABLE    (NAME : NAME_STRING)
                                   return BOOLEAN;
        function  IS_OBTAINABLE
                    (BASE     : NODE_TYPE;
                     KEY      : RELATIONSHIP_KEY;
                     RELATION : RELATION_NAME :=
                                DEFAULT_RELATION)
                                   return BOOLEAN;
        function  IS_SAME          (NODE1 : NODE_TYPE;
                                    NODE2 : NODE_TYPE)
                                   return BOOLEAN;
```

```
function  IS_SAME         (NAME1 : NAME_STRING;
                           NAME2 : NAME_STRING)
                            return BOOLEAN;
procedure GET_PARENT
             (PARENT     : in out NODE_TYPE;
              NODE       : NODE_TYPE;
              INTENT     : INTENTION := (1 => READ);
              TIME_LIMIT : DURATION := NO_DELAY);
procedure COPY_NODE
             (FROM        : NODE_TYPE;
              TO_BASE     : NODE_TYPE;
              TO_KEY      : RELATIONSHIP_KEY;
              TO_RELATION : RELATION_NAME :=
                            DEFAULT_RELATION);
procedure COPY_NODE         (FROM : NODE_TYPE;
                            TO    : NAME_STRING);
procedure COPY_TREE
             (FROM        : NODE_TYPE;
              TO_BASE     : NODE_TYPE;
              TO_KEY      : RELATIONSHIP_KEY;
              TO_RELATION : RELATION_NAME :=
                            DEFAULT_RELATION);
procedure COPY_TREE         (FROM : NODE_TYPE;
                            TO    : NAME_STRING);
procedure RENAME
             (NODE         : NODE_TYPE;
              NEW_BASE     : NODE_TYPE;
              NEW_KEY      : RELATIONSHIP_KEY;
              NEW_RELATION : RELATION_NAME :=
                             DEFAULT_RELATION);
procedure RENAME            (NODE     : NODE_TYPE;
                            NEW_NAME : NAME_STRING);
procedure DELETE_NODE       (NODE : in out NODE_TYPE);
procedure DELETE_NODE       (NAME : NAME_STRING);
procedure DELETE_TREE       (NODE : in out NODE_TYPE);
procedure DELETE_TREE       (NAME : NAME_STRING);
procedure LINK
             (NODE         : NODE_TYPE;
              NEW_BASE     : NODE_TYPE;
              NEW_KEY      : RELATIONSHIP_KEY;
              NEW_RELATION : RELATION_NAME :=
                             DEFAULT_RELATION);
procedure LINK              (NODE : NODE_TYPE;
                            NEW_NAME : NAME_STRING);
procedure UNLINK
             (BASE     : NODE_TYPE;
              KEY      : RELATIONSHIP_KEY;
              RELATION : RELATION_NAME :=
                         DEFAULT_RELATION);
procedure UNLINK            (NAME : NAME_STRING);
procedure ITERATE
             (ITERATOR     : out NODE_ITERATOR;
              NODE         : NODE_TYPE;
              KIND         : NODE_KIND;
              KEY          : RELATIONSHIP_KEY_PATTERN :=
                             "*";
              RELATION     : RELATION_NAME_PATTERN :=
                             DEFAULT_RELATION;
              PRIMARY_ONLY : BOOLEAN := TRUE);
procedure ITERATE
             (ITERATOR     : out NODE_ITERATOR;
              NAME         : NAME_STRING;
              KIND         : NODE_KIND;
              KEY          : RELATIONSHIP_KEY_PATTERN :=
                             "*";
```

```
                  RELATION     : RELATION_NAME_PATTERN :=
                                 DEFAULT_RELATION;
                  PRIMARY_ONLY : BOOLEAN := TRUE);
    function MORE                (ITERATOR : NODE_ITERATOR)
                                 return BOOLEAN;
    procedure GET_NEXT
                 (ITERATOR    : in out NODE_ITERATOR;
                  NEXT_NODE   : in out NODE_TYPE;
                  INTENT      : INTENTION :=
                                (1 => EXISTENCE);
                  TIME_LIMIT : DURATION := NO_DELAY);
    procedure SET_CURRENT_NODE (NODE : NODE_TYPE);
    procedure SET_CURRENT_NODE (NAME : NAME_STRING);
    procedure GET_CURRENT_NODE (NODE : in out NODE_TYPE;
                  INTENT     : INTENTION := (1 => EXISTENCE);
                  TIME_LIMIT : DURATION  := NO_DELAY);

private
    type NODE_ITERATOR is
         (IMPLEMENTATION_DEFINED);
    -- should be defined by implementor

end NODE_MANAGEMENT;

package ATTRIBUTES is
    use NODE_DEFINITIONS;
    use LIST_UTILITIES;

    subtype ATTRIBUTE_NAME is STRING;

    type ATTRIBUTE_ITERATOR is limited private;

    subtype ATTRIBUTE_PATTERN is STRING;

    procedure CREATE_NODE_ATTRIBUTE
                 (NODE        : NODE_TYPE;
                  ATTRIBUTE   : ATTRIBUTE_NAME;
                  VALUE       : LIST_TYPE);
    procedure CREATE_NODE_ATTRIBUTE
                 (NAME        : NAME_STRING;
                  ATTRIBUTE   : ATTRIBUTE_NAME;
                  VALUE       : LIST_TYPE);
    procedure CREATE_PATH_ATTRIBUTE
                 (BASE        : NODE_TYPE;
                  KEY         : RELATIONSHIP_KEY;
                  RELATION    : RELATION_NAME :=
                                DEFAULT_RELATION;
                  ATTRIBUTE   : ATTRIBUTE_NAME;
                  VALUE       : LIST_TYPE);
    procedure CREATE_PATH_ATTRIBUTE
                 (NAME        : NAME_STRING;
                  ATTRIBUTE   : ATTRIBUTE_NAME;
                  VALUE       : LIST_TYPE);
    procedure DELETE_NODE_ATTRIBUTE
                 (NODE        : NODE_TYPE;
                  ATTRIBUTE   : ATTRIBUTE_NAME);
    procedure DELETE_NODE_ATTRIBUTE
                 (NAME        : NAME_STRING;
                  ATTRIBUTE   : ATTRIBUTE_NAME);
    procedure DELETE_PATH_ATTRIBUTE
                 (BASE        : NODE_TYPE;
                  KEY         : RELATIONSHIP_KEY;
                  RELATION    : RELATION_NAME :=
                                DEFAULT_RELATION;
                  ATTRIBUTE   : ATTRIBUTE_NAME);
```

```
procedure DELETE_PATH_ATTRIBUTE
              (NAME      : NAME_STRING;
               ATTRIBUTE : ATTRIBUTE_NAME);
procedure SET_NODE_ATTRIBUTE
              (NODE      : NODE_TYPE;
               ATTRIBUTE : ATTRIBUTE_NAME;
               VALUE     : LIST_TYPE);
procedure SET_NODE_ATTRIBUTE
              (NAME      : NAME_STRING;
               ATTRIBUTE : ATTRIBUTE_NAME;
               VALUE     : LIST_TYPE);
procedure SET_PATH_ATTRIBUTE
              (BASE      : NODE_TYPE;
               KEY       : RELATIONSHIP_KEY;
               RELATION  : RELATION_NAME :=
                           DEFAULT_RELATION;
               ATTRIBUTE : ATTRIBUTE_NAME;
               VALUE     : LIST_TYPE);
procedure SET_PATH_ATTRIBUTE
              (NAME      : NAME_STRING;
               ATTRIBUTE : ATTRIBUTE_NAME;
               VALUE     : LIST_TYPE);
procedure GET_NODE_ATTRIBUTE
              (NODE      : NODE_TYPE;
               ATTRIBUTE : ATTRIBUTE_NAME;
               VALUE     : in out LIST_TYPE);
procedure GET_NODE_ATTRIBUTE
              (NAME      : NAME_STRING;
               ATTRIBUTE : ATTRIBUTE_NAME;
               VALUE     : in out LIST_TYPE);
procedure GET_PATH_ATTRIBUTE
              (BASE      : NODE_TYPE;
               KEY       : RELATIONSHIP_KEY;
               RELATION  : RELATION_NAME :=
                           DEFAULT_RELATION;
               ATTRIBUTE : ATTRIBUTE_NAME;
               VALUE     : in out LIST_TYPE);
procedure GET_PATH_ATTRIBUTE
              (NAME      : NAME_STRING;
               ATTRIBUTE : ATTRIBUTE_NAME;
               VALUE     : in out LIST_TYPE);
procedure NODE_ATTRIBUTE_ITERATE
              (ITERATOR : out ATTRIBUTE_ITERATOR;
               NODE     : NODE_TYPE;
               PATTERN  : ATTRIBUTE_PATTERN := "*");
procedure NODE_ATTRIBUTE_ITERATE
              (ITERATOR : out ATTRIBUTE_ITERATOR;
               NAME     : NAME_STRING;
               PATTERN  : ATTRIBUTE_PATTERN := "*");
procedure PATH_ATTRIBUTE_ITERATE
              (ITERATOR : out ATTRIBUTE_ITERATOR;
               BASE     : NODE_TYPE;
               KEY      : RELATIONSHIP_KEY;
               RELATION : RELATION_NAME :=
                          DEFAULT_RELATION;
               PATTERN  : ATTRIBUTE_PATTERN := "*");
procedure PATH_ATTRIBUTE_ITERATE
              (ITERATOR : out ATTRIBUTE_ITERATOR;
               NAME     : NAME_STRING;
               PATTERN  : ATTRIBUTE_PATTERN := "*");
function  MORE
              (ITERATOR : ATTRIBUTE_ITERATOR)
                                return BOOLEAN;
procedure GET_NEXT
              (ITERATOR  : in out ATTRIBUTE_ITERATOR;
```

```
                    ATTRIBUTE : out ATTRIBUTE_NAME;
                    VALUE     : in out LIST_TYPE);

    private
        type ATTRIBUTE_ITERATOR is (IMPLEMENTATION_DEFINED);
        -- should be defined by implementor

    end ATTRIBUTES;

    package ACCESS_CONTROL is
        use NODE_DEFINITIONS;

        subtype GRANT_VALUE is CAIS.LIST_UTILITIES.LIST_TYPE;
        procedure SET_ACCESS_CONTROL
                   (NODE      : NODE_TYPE;
                    ROLE_NODE : NODE_TYPE;
                    GRANT     : GRANT_VALUE);
        procedure SET_ACCESS_CONTROL
                   (NAME      : NAME_STRING;
                    ROLE_NAME : NAME_STRING;
                    GRANT     : GRANT_VALUE);
        function  IS_GRANTED
                   (OBJECT_NODE    : NODE_TYPE;
                    ACCESS_RIGHT   : NAME_STRING)
                                     return BOOLEAN;
        function  IS_GRANTED         (OBJECT_NAME  : NAME_STRING;
                                     ACCESS_RIGHT : NAME_STRING)
                                     return BOOLEAN;
        procedure ADOPT              (ROLE_NODE : NODE_TYPE;
                                     ROLE_KEY  : RELATIONSHIP_KEY :=
                                     LATEST_KEY);
        procedure UNADOPT            (ROLE_KEY  : RELATIONSHIP_KEY);
    end ACCESS_CONTROL;

    package STRUCTURAL_NODES is
        use NODE_DEFINITIONS;
        use LIST_UTILITIES;

        procedure CREATE_NODE
                   (NODE           : in out NODE_TYPE;
                    BASE           : NODE_TYPE;
                    KEY            : RELATIONSHIP_KEY :=
                                     LATEST_KEY;
                    RELATION       : RELATION_NAME :=
                                     DEFAULT_RELATION;
                    ATTRIBUTES     : LIST_TYPE := EMPTY_LIST;
                    ACCESS_CONTROL : LIST_TYPE := EMPTY_LIST;
                    LEVEL          : FORM_STRING := EMPTY_LIST);
        procedure CREATE_NODE
                   (NODE           : in out NODE_TYPE;
                    NAME           : NAME_STRING;
                    ATTRIBUTES     : LIST_TYPE := EMPTY_LIST;
                    ACCESS_CONTROL : LIST_TYPE := EMPTY_LIST;
                    LEVEL          : FORM_STRING := EMPTY_LIST);
        procedure CREATE_NODE
                   (BASE           : NODE_TYPE;
                    KEY            : RELATIONSHIP_KEY :=
                                     LATEST_KEY;
                    RELATION       : RELATION_NAME :=
                                     DEFAULT_RELATION;
                    ATTRIBUTES     : LIST_TYPE := EMPTY_LIST;
                    ACCESS_CONTROL : LIST_TYPE := EMPTY_LIST;
                    LEVEL          : FORM_STRING := EMPTY_LIST);
        procedure CREATE_NODE
                   (NAME           : NAME_STRING;
```

```
                    ATTRIBUTES     : LIST_TYPE := EMPTY_LIST;
                    ACCESS_CONTROL : LIST_TYPE := EMPTY_LIST;
                    LEVEL          : FORM_STRING := EMPTY_LIST);
end STRUCTURAL_NODES;

package PROCESS_DEFINITIONS is
    use NODE_DEFINITIONS;
    use LIST_UTILITIES;

    type PROCESS_STATUS is
        (READY,      SUSPENDED,  ABORTED,    TERMINATED);

    subtype RESULTS_LIST   is CAIS.LIST_UTILITIES.LIST_TYPE;
    subtype RESULTS_STRING is STRING;
    subtype PARAMETER_LIST is CAIS.LIST_UTILITIES.LIST_TYPE;

    ROOT_PROCESS   : constant NAME_STRING := "'CURRENT_JOB";
    CURRENT_INPUT  : constant NAME_STRING :=
                     "'CURRENT_INPUT";
    CURRENT_OUTPUT : constant NAME_STRING :=
                     "'CURRENT_OUTPUT";
    CURRENT_ERROR  : constant NAME_STRING :=
                     "'CURRENT_ERROR";

end PROCESS_DEFINITIONS;

package PROCESS_CONTROL is
    use NODE_DEFINITIONS;
    use LIST_UTILITIES;
    use PROCESS_DEFINITIONS;


    procedure SPAWN_PROCESS
                (NODE             : in out NODE_TYPE;
                 FILE_NODE        : NODE_TYPE;
                 INPUT_PARAMETERS : PARAMETER_LIST := "";
                 KEY              : RELATIONSHIP_KEY :=
                                    LATEST_KEY;
                 RELATION         : RELATION_NAME :=
                                    DEFAULT_RELATION;
                 ACCESS_CONTROL : LIST_TYPE := EMPTY_LIST;
                 LEVEL            : LIST_TYPE := EMPTY_LIST;
                 ATTRIBUTES       : LIST_TYPE :=
                                    EMPTY_LIST;
                 INPUT_FILE       : NAME_STRING :=
                                    CURRENT_INPUT;
                 OUTPUT_FILE      : NAME_STRING :=
                                    CURRENT_OUTPUT;
                 ERROR_FILE       : NAME_STRING :=
                                    CURRENT_ERROR;
                 ENVIRONMENT_NODE : NAME_STRING :=
                                    CURRENT_NODE);
    procedure AWAIT_PROCESS_COMPLETION
                (NODE             : NODE_TYPE;
                 TIME_LIMIT       : DURATION := DURATION'LAST);
    procedure AWAIT_PROCESS_COMPLETION
                (NODE             : NODE_TYPE;
                 RESULTS_RETURNED : in out RESULTS_LIST;
                 STATUS           : out PROCESS_STATUS;
                 TIME_LIMIT       : DURATION :=
                                    DURATION'LAST);
    procedure INVOKE_PROCESS
                (NODE             : in out NODE_TYPE;
                 FILE_NODE        : NODE_TYPE;
```

```
                RESULTS_RETURNED : in out RESULTS_LIST;
                STATUS           : out PROCESS_STATUS;
                INPUT_PARAMETERS : PARAMETER_LIST := "";
                KEY              : RELATIONSHIP_KEY :=
                                   LATEST_KEY;
                RELATION         : RELATION_NAME :=
                                   DEFAULT_RELATION;
                ACCESS_CONTROL : LIST_TYPE := EMPTY_LIST;
                LEVEL            : LIST_TYPE := EMPTY_LIST;
                ATTRIBUTES       : LIST_TYPE :=
                                   EMPTY_LIST;
                INPUT_FILE       : NAME_STRING :=
                                   CURRENT_INPUT;
                OUTPUT_FILE      : NAME_STRING :=
                                   CURRENT_OUTPUT;
                ERROR_FILE       : NAME_STRING :=
                                   CURRENT_ERROR;
                ENVIRONMENT_NODE : NAME_STRING :=
                                   CURRENT_NODE;
                TIME_LIMIT       : DURATION :=
                                   DURATION'LAST);
procedure CREATE_JOB
               (FILE_NODE        : NODE_TYPE;
                INPUT_PARAMETERS : PARAMETER_LIST;
                KEY              : RELATIONSHIP_KEY :=
                                   LATEST_KEY;
                ACCESS_CONTROL : LIST_TYPE := EMPTY_LIST;
                LEVEL            : LIST_TYPE := EMPTY_LIST;
                ATTRIBUTES       : LIST_TYPE :=
                                   EMPTY_LIST;
                INPUT_FILE       : NAME_STRING :=
                                   CURRENT_INPUT;
                OUTPUT_FILE      : NAME_STRING :=
                                   CURRENT_OUTPUT;
                ERROR_FILE       : NAME_STRING :=
                                   CURRENT_ERROR;
                ENVIRONMENT_NODE : NAME_STRING :=
                                   CURRENT_USER);
procedure APPEND_RESULTS
               (RESULTS : RESULTS_STRING);
procedure WRITE_RESULTS
               (RESULTS : RESULTS_STRING);
procedure GET_RESULTS
               (NODE    : NODE_TYPE;
                RESULTS : in out RESULTS_LIST);
procedure GET_RESULTS
               (NODE    : NODE_TYPE;
                RESULTS : in out RESULTS_LIST;
                STATUS  : out PROCESS_STATUS);
procedure GET_RESULTS
               (NAME    : NAME_STRING;
                RESULTS : in out RESULTS_LIST;
                STATUS  : out PROCESS_STATUS);
procedure GET_RESULTS
               (NAME    : NAME_STRING;
                RESULTS : in out RESULTS_LIST);
procedure GET_PARAMETERS
               (PARAMETERS : in out PARAMETER_LIST);
procedure ABORT_PROCESS
               (NODE    : NODE_TYPE;
                RESULTS : RESULTS_STRING);
procedure ABORT_PROCESS
               (NAME    : NAME_STRING;
                RESULTS : RESULTS_STRING);
procedure ABORT_PROCESS          (NODE : NODE_TYPE);
```

```
          procedure ABORT_PROCESS         (NAME : NAME_STRING);
          procedure SUSPEND_PROCESS       (NODE : NODE_TYPE);
          procedure SUSPEND_PROCESS       (NAME : NAME_STRING);
          procedure RESUME_PROCESS        (NODE : NODE_TYPE);
          procedure RESUME_PROCESS        (NAME : NAME_STRING);
          function  STATUS_OF_PROCESS     (NODE : NODE_TYPE)
                                          return PROCESS_STATUS;
          function  STATUS_OF_PROCESS     (NAME : NAME_STRING)
                                          return PROCESS_STATUS;
          function  HANDLES_OPEN          (NODE : NODE_TYPE)
                                          return NATURAL;
          function  HANDLES_OPEN          (NAME : NAME_STRING)
                                          return NATURAL;
          function  IO_UNITS              (NODE : NODE_TYPE)
                                          return NATURAL;
          function  IO_UNITS              (NAME : NAME_STRING)
                                          return NATURAL;
          function  START_TIME            (NODE : NODE_TYPE)
                                          return TIME;
          function  START_TIME            (NAME : NAME_STRING)
                                          return TIME;
          function  FINISH_TIME           (NODE : NODE_TYPE)
                                          return TIME;
          function  FINISH_TIME           (NAME : NAME_STRING)
                                          return TIME;
          function  MACHINE_TIME          (NODE : NODE_TYPE)
                                          return DURATION;
          function  MACHINE_TIME          (NAME : NAME_STRING)
                                          return DURATION;

     end PROCESS_CONTROL;

     package IO_DEFINITIONS is
          use NODE_DEFINITIONS;
          use LIST_UTILITIES;

          type FILE_TYPE is limited private;
          type FILE_MODE is
               (IN_FILE,    INOUT_FILE,  OUT_FILE,
                APPEND_FILE);
          type CHARACTER_ARRAY         is array (CHARACTER)
                                                of BOOLEAN;
          type FUNCTION_KEY_DESCRIPTOR(LENGTH : POSITIVE) is private;
          type TAB_ENUMERATION is (HORIZONTAL, VERTICAL);
          type POSITION_TYPE is
               record
                    ROW    : NATURAL;
                    COLUMN : NATURAL;
               end record;
               private
               type FILE_TYPE is (IMPLEMENTATION_DEFINED);
               -- should be defined by implementor
               type FUNCTION_KEY_DESCRIPTOR(LINK: POSITIVE) is
               record
               null; -- defined by implementor
               end record;

end IO_DEFINITIONS;

package IO_CONTROL is
          use IO_DEFINITIONS;
          use NODE_DEFINITIONS;
          use LIST_UTILITIES;
```

```
procedure OPEN_FILE_NODE
            (FILE       : FILE_TYPE;
             NODE       : in out NODE_TYPE;
             INTENT     : in INTENTION;
             TIME_LIMIT : in DURATION := NO_DELAY);
procedure SYNCHRONIZE
            (FILE : FILE_TYPE);
procedure SET_LOG
            (FILE     : FILE_TYPE;
             LOG_FILE : FILE_TYPE);
procedure CLEAR_LOG(FILE : FILE_TYPE);
function  LOGGING                  (FILE : FILE_TYPE)
                                    return BOOLEAN;
function  GET_LOG                  (FILE : FILE_TYPE)
                                    return FILE_TYPE;
function  NUMBER_OF_ELEMENTS       (FILE : FILE_TYPE)
                                    return NATURAL;
procedure SET_PROMPT               (TERMINAL : FILE_TYPE;
                                   PROMPT   : STRING);
function  GET_PROMPT               (TERMINAL : FILE_TYPE)
                                    return STRING;
function  INTERCEPTED_CHARACTERS   (TERMINAL : FILE_TYPE)
                                    return CHARACTER_ARRAY;
procedure ENABLE_FUNCTION_KEYS     (TERMINAL : FILE_TYPE;
                                   ENABLE   : BOOLEAN);
function  FUNCTION_KEYS_ENABLED    (TERMINAL : FILE_TYPE)
                                    return BOOLEAN;
procedure COUPLE
            (QUEUE_BASE     : NODE_TYPE;
             QUEUE_KEY      : RELATIONSHIP_KEY :=
                              LATEST_KEY;
             QUEUE_RELATION : RELATION_NAME :=
                              DEFAULT_RELATION;
             FILE_NODE      : NODE_TYPE;
             FORM           : LIST_TYPE := EMPTY_LIST;
             ATTRIBUTES     : LIST_TYPE; -- intentionally no default
             ACCESS_CONTROL : LIST_TYPE := EMPTY_LIST;
             LEVEL          : FORM_STRING := EMPTY_LIST);
procedure COUPLE
            (QUEUE_NAME     : NAME_STRING;
             FILE_NODE      : NODE_TYPE;
             FORM           : LIST_TYPE := EMPTY_LIST;
             ATTRIBUTES     : LIST_TYPE;
             ACCESS_CONTROL : LIST_TYPE := EMPTY_LIST;
             LEVEL          : FORM_STRING := EMPTY_LIST);
procedure COUPLE
            (QUEUE_BASE     : NODE_TYPE;
             QUEUE_KEY      : RELATIONSHIP_KEY :=
                              LATEST_KEY;
             QUEUE_RELATION : RELATION_NAME :=
                              DEFAULT_RELATION;
             FILE_NAME      : NAME_STRING;
             FORM           : LIST_TYPE := EMPTY_LIST;
             ATTRIBUTES     : LIST_TYPE;
             ACCESS_CONTROL : LIST_TYPE := EMPTY_LIST;
             LEVEL          : FORM_STRING := EMPTY_LIST);
procedure COUPLE
            (QUEUE_NAME     : NAME_STRING;
             FILE_NAME      : NAME_STRING;
             FORM           : LIST_TYPE := EMPTY_LIST;
             ATTRIBUTES     : LIST_TYPE;
             ACCESS_CONTROL : LIST_TYPE := EMPTY_LIST;
             LEVEL          : FORM_STRING := EMPTY_LIST);
```

```
end IO_CONTROL;

generic
    type ELEMENT_TYPE is private;
package DIRECT_IO is
    use NODE_DEFINITIONS;
    use LIST_UTILITIES;
    use IO_DEFINITIONS;

    type COUNT is range 0 .. INTEGER'LAST;
    subtype POSITIVE_COUNT is COUNT range 1 .. COUNT'LAST;

    -- File management

    procedure CREATE (FILE           : in out FILE_TYPE;
                      BASE           : NODE_TYPE;
                      KEY            : RELATIONSHIP_KEY :=
                                       LATEST_KEY;
                      RELATION       : RELATION_NAME :=
                                       DEFAULT_RELATION;
                      MODE           : FILE_MODE :=
                                       INOUT_FILE;
                      FORM           : LIST_TYPE :=
                                       EMPTY_LIST;
                      ATTRIBUTES     : LIST_TYPE :=
                                       EMPTY_LIST;
                      ACCESS_CONTROL : LIST_TYPE := EMPTY_LIST;
                      LEVEL          : FORM_STRING := EMPTY_LIST);
    procedure CREATE (FILE           : in out FILE_TYPE;
                      NAME           : NAME_STRING;
                      MODE           : FILE_MODE :=
                                       INOUT_FILE;
                      FORM           : LIST_TYPE :=
                                       EMPTY_LIST;
                      ATTRIBUTES     : LIST_TYPE :=
                                       EMPTY_LIST;
                      ACCESS_CONTROL : LIST_TYPE := EMPTY_LIST;
                      LEVEL          : FORM_STRING := EMPTY_LIST);
    procedure OPEN   (FILE : in out FILE_TYPE;
                      NODE : NODE_TYPE;
                      MODE : FILE_MODE := INOUT_FILE);
    procedure OPEN   (FILE : in out FILE_TYPE;
                      NAME : NAME_STRING;
                      MODE : FILE_MODE := INOUT_FILE);

    procedure CLOSE  (FILE : in out FILE_TYPE);
    procedure DELETE (FILE : in out FILE_TYPE);
    procedure RESET  (FILE : in out FILE_TYPE;
                      MODE : FILE_MODE);

    function MODE (FILE : FILE_TYPE) return FILE_MODE;
    function NAME (FILE : FILE_TYPE) return STRING;
    function FORM (FILE : FILE_TYPE) return STRING;

    function IS_OPEN (FILE : FILE_TYPE) return BOOLEAN;
    -- Input and output operations

    procedure READ (FILE : FILE_TYPE;
                    ITEM : out ELEMENT_TYPE;
                    FROM : POSITIVE_COUNT);
    procedure READ (FILE : FILE_TYPE;
                    ITEM : out ELEMENT_TYPE);

    procedure WRITE (FILE : FILE_TYPE;
```

```
                    ITEM : ELEMENT_TYPE;
                    TO   : POSITIVE_COUNT);
    procedure WRITE (FILE : FILE_TYPE;
                    ITEM : ELEMENT_TYPE);

    procedure SET_INDEX (FILE : FILE_TYPE;
                         TO   : POSITIVE_COUNT);

    function INDEX (FILE : FILE_TYPE) return POSITIVE_COUNT;
    function SIZE  (FILE : FILE_TYPE) return COUNT;

    function END_OF_FILE (FILE : FILE_TYPE) return BOOLEAN;

end DIRECT_IO;

generic
    type ELEMENT_TYPE is private;
package SEQUENTIAL_IO is
    use NODE_DEFINITIONS;
    use LIST_UTILITIES;
    use IO_DEFINITIONS;


    -- File management


    procedure CREATE (FILE           : in out FILE_TYPE;
                      BASE           : NODE_TYPE;
                      KEY            : RELATIONSHIP_KEY :=
                                       LATEST_KEY;
                      RELATION       : RELATION_NAME :=
                                       DEFAULT_RELATION;
                      MODE           : FILE_MODE :=
                                       INOUT_FILE;
                      FORM           : LIST_TYPE :=
                                       EMPTY_LIST;
                      ATTRIBUTES     : LIST_TYPE :=
                                       EMPTY_LIST;
                      ACCESS_CONTROL : LIST_TYPE := EMPTY_LIST;
                      LEVEL          : FORM_STRING := EMPTY_LIST);
    procedure CREATE (FILE           : in out FILE_TYPE;
                      NAME           : NAME_STRING;
                      MODE           : FILE_MODE :=
                                       INOUT_FILE;
                      FORM           : LIST_TYPE :=
                                       EMPTY_LIST;
                      ATTRIBUTES     : LIST_TYPE :=
                                       EMPTY_LIST;
                      ACCESS_CONTROL : LIST_TYPE := EMPTY_LIST;
                      LEVEL          : FORM_STRING := EMPTY_LIST);
    procedure OPEN   (FILE : in out FILE_TYPE;
                      NODE : NODE_TYPE;
                      MODE : FILE_MODE);
    procedure OPEN   (FILE : in out FILE_TYPE;
                      NAME : NAME_STRING;
                      MODE : FILE_MODE );

    procedure CLOSE  (FILE : in out FILE_TYPE);
    procedure DELETE (FILE : in out FILE_TYPE);
    procedure RESET  (FILE : in out FILE_TYPE;
                      MODE : FILE_MODE);
    procedure RESET  (FILE : in out FILE_TYPE);

    function MODE (FILE : FILE_TYPE) return FILE_MODE;
    function NAME (FILE : FILE_TYPE) return STRING;
```

```
    function FORM (FILE : FILE_TYPE) return STRING;

    function is_OPEN (FILE : FILE_TYPE) return BOOLEAN;

    -- Input and output operations

    procedure READ  (FILE : FILE_TYPE;
                     ITEM : out ELEMENT_TYPE);
    procedure WRITE (FILE : FILE_TYPE;
                     ITEM : ELEMENT_TYPE);

    function END_OF_FILE (FILE : FILE_TYPE) return BOOLEAN;
end SEQUENTIAL_IO;

package TEXT_IO is
    use NODE_DEFINITIONS;
    use LIST_UTILITIES;
    use IO_DEFINITIONS;

    type COUNT is range 0 .. INTEGER'LAST;

    subtype POSITIVE_COUNT is COUNT range 1 .. COUNT'LAST;

    UNBOUNDED : constant COUNT := 0; -- line and page length

    subtype FIELD       is INTEGER range 0 .. INTEGER'LAST;
    subtype NUMBER_BASE is INTEGER range 2 .. 16;

    type TYPE_SET is (LOWER_CASE, UPPER_CASE);


    -- File Management


    procedure CREATE (FILE           : in out FILE_TYPE;
                      BASE           : NODE_TYPE;
                      KEY            : RELATIONSHIP_KEY :=
                                       LATEST_KEY;
                      RELATION       : RELATION_NAME :=
                                       DEFAULT_RELATION;
                      MODE           : FILE_MODE :=
                                       INOUT_FILE;
                      FORM           : LIST_TYPE :=
                                       EMPTY_LIST;
                      ATTRIBUTES     : LIST_TYPE :=
                                       EMPTY_LIST;
                      ACCESS_CONTROL : LIST_TYPE := EMPTY_LIST;
                      LEVEL          : FORM_STRING := EMPTY_LIST);
    procedure CREATE (FILE           : in out FILE_TYPE;
                      NAME           : NAME_STRING;
                      MODE           : FILE_MODE :=
                                       INOUT_FILE;
                      FORM           : LIST_TYPE :=
                                       EMPTY_LIST;
                      ATTRIBUTES     : LIST_TYPE :=
                                       EMPTY_LIST;
                      ACCESS_CONTROL : LIST_TYPE := EMPTY_LIST;
                      LEVEL          : FORM_STRING := EMPTY_LIST);
    procedure OPEN   (FILE : in out FILE_TYPE;
                      NODE : NODE_TYPE;
                      MODE : FILE_MODE);
    procedure OPEN   (FILE : in out FILE_TYPE;
                      NAME : NAME_STRING;
                      MODE : FILE_MODE);
```

```
procedure CLOSE  (FILE : in out FILE_TYPE);
procedure DELETE (FILE : in out FILE_TYPE);
procedure RESET  (FILE : in out FILE_TYPE;
                  MODE : FILE_MODE);
procedure RESET  (FILE : in out FILE_TYPE);

function MODE (FILE : FILE_TYPE) return FILE_MODE;
function NAME (FILE : FILE_TYPE) return STRING;
function FORM (FILE : FILE_TYPE) return STRING;

function is_OPEN (FILE : FILE_TYPE) return BOOLEAN;


-- Control of default input and output files

procedure SET_INPUT  (FILE : FILE_TYPE);
procedure SET_OUTPUT (FILE : FILE_TYPE);
procedure SET_ERROR  (FILE : FILE_TYPE);


function STANDARD_INPUT  return FILE_TYPE;
function STANDARD_OUTPUT return FILE_TYPE;
function STANDARD_ERROR  return FILE_TYPE;

function CURRENT_INPUT  return FILE_TYPE;
function CURRENT_OUTPUT return FILE_TYPE;
function CURRENT_ERROR  return FILE_TYPE;


-- Specification of line and page lengths

procedure SET_LINE_LENGTH (FILE : FILE_TYPE;
                           TO   : COUNT);
procedure SET_LINE_LENGTH (TO : COUNT);

procedure SET_PAGE_LENGTH (FILE : FILE_TYPE;
                           TO   : COUNT);
procedure SET_PAGE_LENGTH (TO : COUNT);

function LINE_LENGTH (FILE : FILE_TYPE) return COUNT;
function LINE_LENGTH return COUNT;

function PAGE_LENGTH (FILE : FILE_TYPE) return COUNT;
function PAGE_LENGTH return COUNT;


-- Column, Line and Page Control

procedure NEW_LINE (FILE    : FILE_TYPE;
                    SPACING : POSITIVE_COUNT := 1);
procedure NEW_LINE (SPACING : POSITIVE_COUNT := 1);

procedure SKIP_LINE (FILE    : FILE_TYPE;
                     SPACING : POSITIVE_COUNT := 1);
procedure SKIP_LINE (SPACING : POSITIVE_COUNT := 1);

function END_OF_LINE (FILE : FILE_TYPE) return BOOLEAN;
function END_OF_LINE return BOOLEAN;

procedure NEW_PAGE (FILE : FILE_TYPE);
procedure NEW_PAGE;

procedure SKIP_PAGE (FILE : FILE_TYPE);
procedure SKIP_PAGE;
```

```
function END_OF_PAGE (FILE : FILE_TYPE) return BOOLEAN;
function END_OF_PAGE return BOOLEAN;

function END_OF_FILE (FILE : FILE_TYPE) return BOOLEAN;
function END_OF_FILE return BOOLEAN;


procedure SET_COL (FILE : FILE_TYPE;
                   TO   : POSITIVE_COUNT);
procedure SET_COL (TO : POSITIVE_COUNT);

procedure SET_LINE (FILE : FILE_TYPE;
                    TO   : POSITIVE_COUNT);
procedure SET_LINE (TO : POSITIVE_COUNT);


function COL (FILE : FILE_TYPE) return POSITIVE_COUNT;
function COL return POSITIVE_COUNT;

function LINE (FILE : FILE_TYPE) return POSITIVE_COUNT;
function LINE return POSITIVE_COUNT;

function PAGE (FILE : FILE_TYPE) return POSITIVE_COUNT;
function PAGE return POSITIVE_COUNT;

-- Character Input-Output

procedure GET (FILE : FILE_TYPE;
               ITEM : out CHARACTER);
procedure GET (ITEM : out CHARACTER);
procedure PUT (FILE : FILE_TYPE; ITEM : CHARACTER);
procedure PUT (ITEM : CHARACTER);


-- String Input-Output

procedure GET (FILE : FILE_TYPE; ITEM : out STRING);
procedure GET (ITEM : out STRING);
procedure PUT (FILE : FILE_TYPE; ITEM : STRING);
procedure PUT (ITEM : STRING);

procedure GET_LINE (FILE : FILE_TYPE;
                    ITEM : out STRING;
                    LAST : out NATURAL);
procedure GET_LINE (ITEM : out STRING;
                    LAST : out NATURAL);

procedure PUT_LINE (FILE : FILE_TYPE; ITEM : STRING);
procedure PUT_LINE (ITEM : STRING);


-- generic package for Input-Output of Integer Types

generic
    type NUM is range <>;
package INTEGER_IO is

    DEFAULT_WIDTH : FIELD := NUM'WIDTH;
    DEFAULT_BASE  : NUMBER_BASE := 10;

    procedure GET (FILE  : FILE_TYPE;
                   ITEM  : out NUM;
                   WIDTH : FIELD := 0);
    procedure GET (ITEM  : out NUM;
```

```
                    WIDTH : FIELD := 0);

    procedure PUT (FILE  : FILE_TYPE;
                   ITEM  : NUM;
                   WIDTH : FIELD := DEFAULT_WIDTH;
                   BASE  : NUMBER_BASE := DEFAULT_BASE);
    procedure PUT (ITEM  : NUM;
                   WIDTH : FIELD := DEFAULT_WIDTH;
                   BASE  : NUMBER_BASE := DEFAULT_BASE);

    procedure GET (FROM : STRING;
                   ITEM : out NUM;
                   LAST : out POSITIVE);
    procedure PUT (TO   : out STRING;
                   ITEM : NUM;
                   BASE : NUMBER_BASE := DEFAULT_BASE);

end INTEGER_IO;


-- generic package for Input-Output of Floating Point
-- Types

generic
    type NUM is digits <>;
package FLOAT_IO is

    DEFAULT_FORE : FIELD := 2;
    DEFAULT_AFT  : FIELD := NUM'DIGITS - 1;
    DEFAULT_EXP  : FIELD := 3;


    procedure GET (FILE  : FILE_TYPE;
                   ITEM  : out NUM;
                   WIDTH : FIELD := 0);
    procedure GET (ITEM  : out NUM;
                   WIDTH : FIELD := 0);

    procedure PUT (FILE : FILE_TYPE;
                   ITEM : NUM;
                   FORE : FIELD := DEFAULT_FORE;
                   AFT  : FIELD := DEFAULT_AFT;
                   EXP  : FIELD := DEFAULT_EXP);
    procedure PUT (ITEM : NUM;
                   FORE : FIELD := DEFAULT_FORE;
                   AFT  : FIELD := DEFAULT_AFT;
                   EXP  : FIELD := DEFAULT_EXP);

    procedure GET (FROM : STRING;
                   ITEM : out NUM;
                   LAST : out POSITIVE);
    procedure PUT (TO   : out STRING;
                   ITEM : NUM;
                   AFT  : FIELD := DEFAULT_AFT;
                   EXP  : FIELD := DEFAULT_EXP);

end FLOAT_IO;


-- generic package for Input-Output of Fixed Point Types

generic
    type NUM is delta <>;
package FIXED_IO is
```

```
        DEFAULT_FORE : FIELD := NUM'FORE;
        DEFAULT_AFT  : FIELD := NUM'AFT;
        DEFAULT_EXP  : FIELD := 0;

        procedure GET (FILE  : FILE_TYPE;
                       ITEM  : out NUM;
                       WIDTH : FIELD := 0);
        procedure GET (ITEM  : out NUM;
                       WIDTH : FIELD := 0);

        procedure PUT (FILE : FILE_TYPE;
                       ITEM : NUM;
                       FORE : FIELD := DEFAULT_FORE;
                       AFT  : FIELD := DEFAULT_AFT;
                       EXP  : FIELD := DEFAULT_EXP);
        procedure PUT (ITEM : NUM;
                       FORE : FIELD := DEFAULT_FORE;
                       AFT  : FIELD := DEFAULT_AFT;
                       EXP  : FIELD := DEFAULT_EXP);

        procedure GET (FROM : STRING;
                       ITEM : out NUM;
                       LAST : out POSITIVE);
        procedure PUT (TO   : out STRING;
                       ITEM : NUM;
                       AFT  : FIELD := DEFAULT_AFT;
                       EXP  : FIELD := DEFAULT_EXP);

    end FIXED_IO;


    -- generic) package for Input-Output of Enumeration Types

    generic
        type ENUM is (<>);
    package ENUMERATION_IO is

        DEFAULT_WIDTH   : FIELD := 0;
        DEFAULT_SETTING : TYPE_SET := UPPER_CASE;

        procedure GET (FILE : FILE_TYPE; ITEM : out ENUM);
        procedure GET (ITEM : out ENUM);

        procedure PUT (FILE  : FILE_TYPE;
                       ITEM  : ENUM;
                       WIDTH : FIELD := DEFAULT_WIDTH;
                       SET   : TYPE_SET := DEFAULT_SETTING);
        procedure PUT (ITEM  : ENUM;
                       WIDTH : FIELD := DEFAULT_WIDTH;
                       SFT   : TYPE_SET := DEFAULT_SETTING);

        procedure GET (FROM : STRING;
                       ITEM : out ENUM;
                       LAST : out POSITIVE);
        procedure PUT (TO   : out STRING;
                       ITEM : ENUM;
                       SET  : TYPE_SET := DEFAULT_SETTING);
    end ENUMERATION_IO;

end TEXT_IO;

package SCROLL_TERMINAL is
    use NODE_DEFINITIONS;
    use IO_DEFINITIONS;
```

```
                    (KIND  : TAB_ENUMERATION := HORIZONTAL;
                     COUNT : POSITIVE := 1);
procedure BELL
                    (TERMINAL : FILE_TYPE);
procedure BELL;
procedure PUT (TERMINAL : FILE_TYPE;
                ITEM     : CHARACTER);
procedure PUT (ITEM : CHARACTER);
procedure PUT (TERMINAL : FILE_TYPE;
                ITEM     : STRING);
procedure PUT (ITEM : STRING);
procedure SET_ECHO
                    (TERMINAL : FILE_TYPE;
                     TO       : BOOLEAN := TRUE);
procedure SET_ECHO
                    (TO : BOOLEAN := TRUE);
function  ECHO
                    (TERMINAL : FILE_TYPE) return BOOLEAN;
function  ECHO                             return BOOLEAN;
function  MAXIMUM_FUNCTION_KEYS
                    (TERMINAL : FILE_TYPE) return NATURAL;
function  MAXIMUM_FUNCTION_KEYS return NATURAL;
procedure GET
                    (TERMINAL : FILE_TYPE;
                     ITEM     : out CHARACTER;
                     KEYS     : out FUNCTION_KEY_DESCRIPTOR);
procedure GET
                    (ITEM : out CHARACTER;
                     KEYS : out FUNCTION_KEY_DESCRIPTOR);
procedure GET
                    (TERMINAL : FILE_TYPE;
                     ITEM     : out STRING;
                     LAST     : out NATURAL;
                     KEYS     : out FUNCTION_KEY_DESCRIPTOR);
procedure GET
                    (ITEM : out STRING;
                     LAST : out NATURAL;
                     KEYS : out FUNCTION_KEY_DESCRIPTOR);
function  FUNCTION_KEY_COUNT
                    (KEYS : FUNCTION_KEY_DESCRIPTOR)
                                             return NATURAL;
procedure FUNCTION_KEY
                    (KEYS           : FUNCTION_KEY_DESCRIPTOR;
                     INDEX          : POSITIVE;
                     KEY_IDENTIFIER : out POSITIVE;
                     POSITION       : out NATURAL);
procedure FUNCTION_KEY_NAME
                    (TERMINAL       : FILE_TYPE;
                     KEY_IDENTIFIER : POSITIVE;
                     KEY_NAME       : out STRING;
                     LAST           : out POSITIVE);
procedure FUNCTION_KEY_NAME
                    (KEY_IDENTIFIER : POSITIVE;
                     KEY_NAME       : out STRING;
                     LAST           : out POSITIVE);
procedure DELETE_CHARACTER
                    (TERMINAL : FILE_TYPE;
                     COUNT    : POSITIVE := 1);
procedure DELETE_CHARACTER
                    (COUNT : POSITIVE := 1);
procedure DELETE_LINE
                    (TERMINAL : FILE_TYPE;
                     COUNT    : POSITIVE :=1);
procedure DELETE_LINE
```

```
                (COUNT : POSITIVE := 1);
    procedure ERASE_CHARACTER
                (TERMINAL : FILE_TYPE;
                 COUNT    : POSITIVE := 1);
    procedure ERASE_CHARACTER
                (COUNT : POSITIVE := 1);
    procedure ERASE_IN_DISPLAY
                (TERMINAL  : FILE_TYPE;
                 SELECTION : SELECT_ENUMERATION);
    procedure ERASE_IN_DISPLAY
                (SELECTION : SELECT_ENUMERATION);
    procedure ERASE_IN_LINE
                (TERMINAL  : FILE_TYPE;
                 SELECTION : SELECT_ENUMERATION);
    procedure ERASE_IN_LINE
                (SELECTION : SELECT_ENUMERATION);
    procedure INSERT_SPACE
                (TERMINAL : FILE_TYPE;
                 COUNT    : POSITIVE := 1);
    procedure INSERT_SPACE
                (COUNT : POSITIVE := 1);
    procedure INSERT_LINE
                (TERMINAL : FILE_TYPE;
                 COUNT    : POSITIVE := 1);
    procedure INSERT_LINE(COUNT : POSITIVE := 1);
    function  GRAPHIC_RENDITION_SUPPORT
                (TERMINAL  : FILE_TYPE;
                 RENDITION : GRAPHIC_RENDITION_ARRAY)
                                        return BOOLEAN;
    function  GRAPHIC_RENDITION_SUPPORT
                (RENDITION : GRAPHIC_RENDITION_ARRAY)
                                        return BOOLEAN;
    procedure SELECT_GRAPHIC_RENDITION
                (TERMINAL  : FILE_TYPE;
                 RENDITION : GRAPHIC_RENDITION_ARRAY :=
                             DEFAULT_GRAPHIC_RENDITION);
    procedure SELECT_GRAPHIC_RENDITION
                (RENDITION : GRAPHIC_RENDITION_ARRAY :=
                             DEFAULT_GRAPHIC_RENDITION);

end PAGE_TERMINAL;

package FORM_TERMINAL is
    use NODE_DEFINITIONS;
    use IO_DEFINITIONS;

    type AREA_INTENSITY is (NONE, NORMAL, HIGH);
    type AREA_PROTECTION is (UNPROTECTED, PROTECTED);
    type AREA_INPUT is
         (GRAPHIC_CHARACTERS, NUMERICS,
          ALPHABETICS);
    type AREA_VALUE is
         (NO_FILL, FILL_WITH_ZEROES,
          FILL_WITH_SPACES);

    type FORM_TYPE (ROW                           : POSITIVE;
                    COLUMN                        : POSITIVE;
                    AREA_QUALIFIER_REQUIRES_SPACE : BOOLEAN) is private;

    subtype PRINTABLE_CHARACTER is CHARACTER range ' ' .. '~';


    function  MAXIMUM_FUNCTION_KEYS
                (TERMINAL : FILE_TYPE) return NATURAL;
    function  MAXIMUM_FUNCTION_KEYS return NATURAL;
```

```
procedure DEFINE_QUALIFIED_AREA
                (FORM       : in out FORM_TYPE;
                 INTENSITY  : AREA_INTENSITY := NORMAL;
                 PROTECTION : AREA_PROTECTION := PROTECTED;
                 INPUT      : AREA_INPUT :=
                              GRAPHIC_CHARACTERS;
                 VALUE      : AREA_VALUE := NO_FILL);
procedure REMOVE_AREA_QUALIFIER
                (FORM : in out FORM_TYPE);
procedure SET_POSITION
                (FORM     : in out FORM_TYPE;
                 POSITION : POSITION_TYPE);
procedure NEXT_QUALIFIED_AREA
                (FORM  : in out FORM_TYPE;
                 COUNT : POSITIVE := 1);
procedure PUT
                (FORM : in out FORM_TYPE;
                 ITEM : PRINTABLE_CHARACTER);
procedure PUT
                (FORM : in out FORM_TYPE;
                 ITEM : STRING);
procedure ERASE_AREA
                (FORM : in out FORM_TYPE);
procedure ERASE_FORM
                (FORM : in out FORM_TYPE);
procedure ACTIVATE
                (TERMINAL : FILE_TYPE;
                 FORM     : in out FORM_TYPE);
procedure GET
                (FORM : in out FORM_TYPE;
                 ITEM : out PRINTABLE_CHARACTER);
procedure GET
                (FORM : in out FORM_TYPE;
                 ITEM : out STRING);
function IS_FORM_UPDATED
                (FORM : FORM_TYPE) return BOOLEAN;
function  TERMINATION_KEY
                (FORM : FORM_TYPE) return NATURAL;
function  FORM_SIZE
                (FORM : FORM_TYPE) return POSITION_TYPE;
function  TERMINAL_SIZE
                (TERMINAL : FILE_TYPE) return POSITION_TYPE;
function  TERMINAL_SIZE return POSITION_TYPE;
function  AREA_QUALIFIER_REQUIRES_SPACE
                (FORM : FORM_TYPE) return BOOLEAN;
function  AREA_QUALIFIER_REQUIRES_SPACE
                (TERMINAL : FILE_TYPE) return BOOLEAN;
function  AREA_QUALIFIER_REQUIRES_SPACE return BOOLEAN;

private

   type FORM_TYPE (ROW                           : POSITIVE;
                   COLUMN                        : POSITIVE;
                   AREA_QUALIFIER_REQUIRES_SPACE : BOOLEAN) is
      record
         null; -- should be defined by implementor
      end record;

end FORM_TERMINAL;


package MAGNETIC_TAPE is
    use NODE_DEFINITIONS;
```

```
    use IO_DEFINITIONS;

    type TAPE_POSITION is
         (BEGINNING_OF_TAPE,    PHYSICAL_END_OF_TAPE,
          TAPE_MARK,            OTHER);

    subtype VOLUME_STRING is STRING (1 .. 6).
    subtype FILE_STRING   is STRING (1 .. 17 ;
    subtype REEL_NAME     is STRING;
    subtype FILE_TYPE     is CAIS.IO_DEFINI IONS.FILE_TYPE;
    subtype LABEL_STRING  is STRING (1...80);

    procedure MOUNT(TAPE_DRIVE: in FILE_TYPE;
                    TAPE_NAME: in REEL_N ME;
                    DENSITY: in POSITIVE)
    procedure LOAD_UNLABELED(TAPE_DRIVE: in    E_TYPE;
                             DENSITY:          OSITIVE;
                             BLOCK_SIZE:      POSITIVE);
    procedure INITIALIZE_UNLABELED(TAPE_DRI    in FILE_TYPE);
    procedure LOAD_LABELED(TAPE_DRIVE: in FILE_TYPE;
                           VOLUME_IDENTIFIER: in VOLUME_STRING;
                           DENSITY: in POSITIVE;
                           BLOCK_SIZE: in POSITIVE);
    procedure INITIALIZE_LABELED(TAPE_DRIVE: in FILE_TYPE;
                           VOLUME_IDENTIFIER: in
VOLUME_STRING;
                           ACCESSIBILITY: in CHARACTER :=' ');
    procedure UNLOAD(TAPE_DRIVE: in FILE_TYPE);
    procedure DISMOUNT(TAPE_DRIVE: in FILE_TYPE);
    function IS_LOADED(TAPE_DRIVE: in FILE_TYPE)
             return BOOLEAN;
    function IS_MOUNTED(TAPE_DRIVE: in FILE_TYPE)
             return BOOLEAN;
    function TAPE_STATUS(TAPE_DRIVE: in FILE_TYPE)
             return TAPE_POSITION;
    procedure REWIND_TAPE(TAPE_DRIVE: in FILE_TYPE);
    procedure SKIP_TAPE_MARKS(TAPE_DRIVE: in FILE_TYPE;
                              NUMBER: in INTEGER :=1;
                              TAPE_STATE:  out TAPE_POSITION);
    procedure WRITE_TAPE_MARK(TAPE_DRIVE: FILE_TYPE;
                              NUMBER: POSITIVE :=1;
                              TAPE_STATE: out TAPE_POSITION);
    procedure VOLUME_HEADER(TAPE_DRIVE: FILE_TYPE;
                         VOLUME_IDENTIFIER: VOLUME_STRING;
                         ACCESSIBILITY: CHARACTER :=' ');
    procedure FILE_HEADER(TAPE_DRIVE: FILE_TYPE;
                         FILE_IDENTIFIER: FILE_STRING;
                         EXPIRATION_DATE: STRING :=" 99366";
                         ACCESSIBILITY: CHARACTER :=' ');
    procedure END_FILE_LABEL(TAPE_DRIVE: FILE_TYPE);
    procedure READ_LABEL(TAPE_DRIVE: FILE_TYPE;
                        LABEL: out LABEL_STRING);


  end MAGNETIC_TAPE;
  package FILE_IMPORT_EXPORT is
    use NODE_DEFINITIONS;
    procedure IMPORT (NODE : NODE_TYPE;
              HOST_FILE_NAME : STRING);
    procedure IMPORT(NAME: in NAME_STRING;
              HOST_FILE_NAME: in STRING);
    procedure EXPORT (NODE : NODE_TYPE;
              HOST_FILE_NAME : STRING);
```

```
        procedure EXPORT(NAME: in NAME_STRING;
                         HOST_FILE_NAME: in STRING);

    end FILE_IMPORT_EXPORT;

end CAIS;
```

Appendix C
CAIS Body

```
with CALENDAR;
package body CAIS is

    package body NODE_MANAGEMENT is separate;

    package body ATTRIBUTES is separate;

    package body ACCESS_CONTROL is separate;

    package body STRUCTURAL_NODES is separate;

    package body PROCESS_CONTROL is separate;

    package body DIRECT_IO is separate;

    package body SEQUENTIAL_IO is separate;

    package body TEXT_IO is separate;

    package body IO_CONTROL is separate;

    package body IO_DEFINITIONS is separate;

    package body SCROLL_TERMINAL is separate;

    package body PAGE_TERMINAL is separate;

    package body FORM_TERMINAL is separate;

    package body MAGNETIC_TAPE is separate;

    package body FILE_IMPORT_EXPORT is separate;

    package body LIST_UTILITIES is separate;
end CAIS;

with CALENDAR;
separate (CAIS)
package body NODE_MANAGEMENT is
    use NODE_DEFINITIONS;
    use CALENDAR;

    procedure OPEN(NODE       : in out NODE_TYPE;
                   NAME       : NAME_STRING;
                   INTENT     : INTENTION := (1 => READ);
                   TIME_LIMIT : DURATION := NO_DELAY) is
    begin
     null; -- should be defined by implementor
    end OPEN;

    procedure OPEN(NODE       : in out NODE_TYPE;
                   BASE       : NODE_TYPE;
                   KEY        : RELATIONSHIP_KEY;
                   RELATION   : RELATION_NAME :=
                           DEFAULT_RELATION;
                   INTENT     : INTENTION := (1 => READ);
                   TIME_LIMIT : DURATION := NO_DELAY) is
    begin
     null; - should be defined by implementor
    end OPEN;
```

```
procedure CLOSE(NODE : in out NODE_TYPE) is separate;

procedure CHANGE_INTENT
      (NODE       : in out NODE_TYPE;
       INTENT     : INTENTION;
       TIME_LIMIT : DURATION := NO_DELAY) is separate;

function IS_OPEN(NODE : NODE_TYPE) return BOOLEAN
is
   RESULT : BOOLEAN;
begin
   -- should be defined by implementor
   return RESULT;
end IS_OPEN;

function INTENT_OF(NODE : NODE_TYPE)
         return INTENTION is separate;
function KIND(NODE : NODE_TYPE) return NODE_KIND is separate;

function PRIMARY_NAME(NODE : NODE_TYPE)
         return NAME_STRING is separate;

function PRIMARY_KEY(NODE : NODE_TYPE)
         return RELATIONSHIP_KEY is separate;

function PRIMARY_RELATION(NODE : NODE_TYPE)
         return RELATION_NAME is separate;

function PATH_KEY(NODE : NODE_TYPE)
         return RELATIONSHIP_KEY is separate;

function PATH_RELATION(NODE : NODE_TYPE)
         return RELATION_NAME is separate;

function BASE_PATH(NAME : NAME_STRING)
         return NAME_STRING is separate;

function LAST_RELATION(NAME : NAME_STRING)
         return RELATION_NAME is separate;

function LAST_KEY(NAME : NAME_STRING)
         return RELATIONSHIP_KEY is separate;

function IS_OBTAINABLE(NODE : NODE_TYPE)
         return BOOLEAN is separate;

function IS_OBTAINABLE(NAME : NAME_STRING) return BOOLEAN is
                       NODE   : NODE_TYPE;
                       RESULT : BOOLEAN;
begin
 OPEN (NODE, NAME, (1 => EXISTENCE));
 RESULT := IS_OBTAINABLE (NODE);
 CLOSE (NODE);
 return RESULT;
exception
 when others =>  return FALSE;
end IS_OBTAINABLE;


function IS_OBTAINABLE
         (BASE     : NODE_TYPE;
          KEY      : RELATIONSHIP_KEY;
          RELATION : RELATION_NAME := DEFAULT_RELATION)
            return BOOLEAN is
```

```
 NODE   : NODE_TYPE;
 RESULT : BOOLEAN;
begin
 OPEN (NODE, BASE, KEY, RELATION, (1 => EXISTENC ));
 RESULT := IS_OBTAINABLE (NODE);
 CLOSE (NODE);
 return RESULT;
exception
 when others =>  return FALSE;
end IS_OBTAINABLE;


function IS_SAME(NODE1 : NODE_TYPE;
            NODE2 : NODE_TYPE) return BOOLEAN is separate;

function IS_SAME(NAME1 : NAME_STRING;
            NAME2 : NAME_STRING) return BOOLEAN is
 NODE1, NODE2 : NODE_TYPE;
 RESULT       : BOOLEAN;
begin
 OPEN (NODE1, NAME1, (1 => EXISTENCE));

 begin
     OPEN (NODE2, NAME2, (1 => EXISTENCE));
 exception
     when others =>
      CLOSE (NODE1);
      raise;
 end;

 RESULT := IS_SAME (NODE1, NODE2);
 CLOSE (NODE1);
 CLOSE (NODE2);
 return RESULT;
end IS_SAME;


procedure GET_PARENT
       (PARENT     : in out NODE_TYPE;
        NODE       : NODE_TYPE;
        INTENT     : INTENTION := (1 => READ);
        TIME_LIMIT : DURATION := NO_DELAY) is separate;

procedure COPY_NODE
       (FROM        : NODE_TYPE;
        TO_BASE     : NODE_TYPE;
        TO_KEY      : RELATIONSHIP_KEY;
        TO_RELATION : RELATION_NAME :=
                DEFAULT_RELATION) is separate;

procedure COPY_NODE(FROM : NODE_TYPE;
                    TO   : NAME_STRING) is
TO_BASE : NODE_TYPE;
begin
 OPEN (TO_BASE, BASE_PATH (TO),
       (1 => APPEND_RELATIONSHIPS));
 COPY_NODE
    (FROM, TO_BASE, LAST_KEY (TO), LAST_RELATION (TO));
 CLOSE (TO_BASE);
exception
 when others =>
     CLOSE (TO_BASE);
     raise;
end COPY_NODE;
```

```
procedure COPY_TREE
       (FROM        : NODE_TYPE;
        TO_BASE     : NODE_TYPE;
        TO_KEY      : RELATIONSHIP_KEY;
        TO_RELATION : RELATION_NAME :=
               DEFAULT_RELATION) is separate;

procedure COPY_TREE(FROM : NODE_TYPE;
                    TO   : NAME_STRING) is
 TO_BASE : NODE_TYPE;
begin
 OPEN (TO_BASE, BASE_PATH (TO),
       (1 => APPEND_RELATIONSHIPS));
 COPY_TREE
    (FROM, TO_BASE, LAST_KEY (TO), LAST_RELATION (TO));
 CLOSE (TO_BASE);
exception
 when others =>
     CLOSE (TO_BASE);
     raise;
end COPY_TREE;


procedure RENAME(NODE         : NODE_TYPE;
                 NEW_BASE     : NODE_TYPE;
                 NEW_KEY      : RELATIONSHIP_KEY;
                 NEW_RELATION : RELATION_NAME :=
                 DEFAULT_RELATION) is separate;

procedure RENAME(NODE     : NODE_TYPE;
                 NEW_NAME : NAME_STRING) is
NEW_BASE : NODE_TYPE;
begin
 OPEN (NEW_BASE, BASE_PATH (NEW_NAME),
       (1 => APPEND_RELATIONSHIPS));
 RENAME
    (NODE, NEW_BASE, LAST_KEY (NEW_NAME),
     LAST_RELATION (NEW_NAME));
 CLOSE (NEW_BASE);
exception
 when others =>
     CLOSE (NEW_BASE);
     raise;
end RENAME;


procedure DELETE_NODE(NODE : in out NODE_TYPE) is separate;

procedure DELETE_NODE(NAME : NAME_STRING) is
 NODE : NODE_TYPE;
begin
 OPEN (NODE, NAME, (EXCLUSIVE_WRITE, READ_RELATIONSHIPS));
 DELETE_NODE (NODE);
exception
 when others =>
     CLOSE (NODE);
     raise;
end DELETE_NODE;


procedure DELETE_TREE(NODE : in out NODE_TYPE) is separate;

procedure DELETE_TREE(NAME : NAME_STRING) is
 NODE : NODE_TYPE;
begin
```

```
 OPEN (NODE, NAME, (EXCLUSIVE_WRITE, READ_RELATIONSHIPS));
 DELETE_TREE (NODE);
exception
 when others =>
     CLOSE (NODE);
     raise;
end DELETE_TREE;


procedure LINK(NODE          : NODE_TYPE;
               NEW_BASE      : NODE_TYPE;
               NEW_KEY       : RELATIONSHIP_KEY;
               NEW_RELATION : RELATION_NAME :=
                  DEFAULT_RELATION) is separate;

procedure LINK(NODE : NODE_TYPE;
                    NEW_NAME : NAME_STRING) is
NEW_BASE : NODE_TYPE;
begin
 OPEN (NEW_BASE, BASE_PATH (NEW_NAME),
       (1 => APPEND_RELATIONSHIPS));
 LINK (NODE, NEW_BASE, LAST_KEY (NEW_NAME),
       LAST_RELATION (NEW_NAME));
 CLOSE (NEW_BASE);
exception
 when others =>
     CLOSE (NEW_BASE);
     raise;
end LINK;


procedure UNLINK(BASE      : NODE_TYPE;
                 KEY       : RELATIONSHIP_KEY;
                 RELATION : RELATION_NAME :=
             DEFAULT_RELATION) is separate;

procedure UNLINK(NAME : NAME_STRING) is
 BASE : NODE_TYPE;
begin
 OPEN (BASE, BASE_PATH (NAME),
       (1 => WRITE_RELATIONSHIPS));
 UNLINK (BASE, LAST_KEY (NAME), LAST_RELATION (NAME));
 CLOSE (BASE);
exception
 when others =>
     CLOSE (BASE);
     raise;
end UNLINK;


procedure ITERATE
       (ITERATOR     : out NODE_ITERATOR;
        NODE         : NODE_TYPE;
        KIND         : NODE_KIND;
        KEY          : RELATIONSHIP_KEY_PATTERN :=
                "*";
        RELATION     : RELATION_NAME_PATTERN :=
                DEFAULT_RELATION;
        PRIMARY_ONLY : BOOLEAN := TRUE) is separate;

procedure ITERATE
       (ITERATOR     : out NODE_ITERATOR;
        NAME         : NAME_STRING;
        KIND         : NODE_KIND;
        KEY          : RELATIONSHIP_KEY_PATTERN :=
```

```
                         "*";
              RELATION      : RELATION_NAME_PATTERN :=
                             DEFAULT_RELATION;
              PRIMARY_ONLY : BOOLEAN := TRUE) is
       NODE : NODE_TYPE;
      begin
       OPEN (NODE, NAME, (1 => READ_RELATIONSHIPS));
       ITERATE (ITERATOR, NODE, KIND, KEY, RELATION,
             PRIMARY_ONLY);
       CLOSE (NODE);
      exception
       when others =>
          CLOSE (NODE);
          raise;
      end ITERATE;


      function MORE (ITERATOR : NODE_ITERATOR) return BOOLEAN
      is
        RESULT : BOOLEAN;
      begin
        -- should be defined by implementor
        return RESULT;
      end MORE;

      procedure GET_NEXT
             (ITERATOR   : in out NODE_ITERATOR;
              NEXT_NODE  : in out NODE_TYPE;
              INTENT     : INTENTION := (1 => EXISTENCE);
              TIME_LIMIT : DURATION := NO_DELAY)
      is
      begin
        null;  -- should be defined by implementor
      end GET_NEXT;

      procedure SET_CURRENT_NODE(NODE : NODE_TYPE) is separate;

      procedure SET_CURRENT_NODE(NAME : NAME_STRING) is
       NODE : NODE_TYPE;
      begin
       OPEN (NODE, NAME, (1 => EXISTENCE));
       SET_CURRENT_NODE (NODE);
      exception
       when others =>
          CLOSE (NODE);
          raise;
      end SET_CURRENT_NODE;


      procedure GET_CURRENT_NODE(NODE : in out NODE_TYPE;
              INTENT     : in : INTENTION := (1 => EXISTENCE);
              TIME_LIMIT : in DURATION := NO_DELAY) is separate;
  end NODE_MANAGEMENT;

  separate (CAIS)
  package body ATTRIBUTES is
      use NODE_DEFINITIONS;
      use NODE_MANAGEMENT;
      use LIST_UTILITIES;

      procedure CREATE_NODE_ATTRIBUTE
             (NODE      : NODE_TYPE;
              ATTRIBUTE : ATTRIBUTE_NAME;
              VALUE     : LIST_TYPE) is separate;
```

```
procedure CREATE_NODE_ATTRIBUTE
        (NAME       : NAME_STRING;
         ATTRIBUTE  : ATTRIBUTE_NAME;
         VALUE      : LIST_TYPE) is
 NODE : NODE_TYPE;
begin
 OPEN (NODE, NAME, (1 => APPEND_RELATIONSHIPS));
 CREATE_NODE_ATTRIBUTE (NODE, ATTRIBUTE, VALUE);
 CLOSE (NODE);
exception
 when others =>
     CLOSE (NODE);
     raise;
end CREATE_NODE_ATTRIBUTE;


procedure CREATE_PATH_ATTRIBUTE
        (BASE       : NODE_TYPE;
         KEY        : RELATIONSHIP_KEY;
         RELATION   : RELATION_NAME :=
                    DEFAULT_RELATION;
         ATTRIBUTE  : ATTRIBUTE_NAME;
         VALUE      : LIST_TYPE) is separate;

procedure CREATE_PATH_ATTRIBUTE
        (NAME       : NAME_STRING;
         ATTRIBUTE  : ATTRIBUTE_NAME;
         VALUE      : LIST_TYPE) is
 BASE : NODE_TYPE;
begin
 OPEN (BASE, BASE_PATH (NAME),
        (1 => WRITE_RELATIONSHIPS));
 CREATE_PATH_ATTRIBUTE
     (BASE, LAST_KEY (NAME), LAST_RELATION (NAME),
      ATTRIBUTE, VALUE);
 CLOSE (BASE);
exception
 when others =>
     CLOSE (BASE);
     raise;
end CREATE_PATH_ATTRIBUTE;


procedure DELETE_NODE_ATTRIBUTE
        (NODE       : NODE_TYPE;
         ATTRIBUTE  : ATTRIBUTE_NAME) is separate;

procedure DELETE_NODE_ATTRIBUTE
        (NAME       : NAME_STRING;
         ATTRIBUTE  : ATTRIBUTE_NAME) is
 NODE : NODE_TYPE;
begin
 OPEN (NODE, NAME, (1 => WRITE_ATTRIBUTES));
 DELETE_NODE_ATTRIBUTE (NODE, ATTRIBUTE);
 CLOSE (NODE);
exception
 when others =>
     CLOSE (NODE);
     raise;
end DELETE_NODE_ATTRIBUTE;


procedure DELETE_PATH_ATTRIBUTE
        (BASE       : NODE_TYPE;
         KEY        : RELATIONSHIP_KEY;
```

```
        RELATION   : RELATION_NAME :=
                     DEFAULT_RELATION;
        ATTRIBUTE  : ATTRIBUTE_NAME) is separate;

procedure DELETE_PATH_ATTRIBUTE
       (NAME       : NAME_STRING;
        ATTRIBUTE  : ATTRIBUTE_NAME) is
BASE : NODE_TYPE;
begin
 OPEN (BASE, BASE_PATH (NAME),
       (1 => WRITE_RELATIONSHIPS));
 DELETE_PATH_ATTRIBUTE
    (BASE, LAST_KEY (NAME), LAST_RELATION (NAME),
     ATTRIBUTE);
 CLOSE (BASE);
exception
 when others =>
     CLOSE (BASE);
     raise;
end DELETE_PATH_ATTRIBUTE;


procedure SET_NODE_ATTRIBUTE(NODE      : NODE_TYPE;
                   ATTRIBUTE : ATTRIBUTE_NAME;
                   VALUE     : LIST_TYPE) is separate;

procedure SET_NODE_ATTRIBUTE(NAME      : NAME_STRING;
                   ATTRIBUTE : ATTRIBUTE_NAME;
                   VALUE     : LIST_TYPE) is
 NODE : NODE_TYPE;
begin
 OPEN (NODE, NAME, (1 => WRITE_ATTRIBUTES));
 SET_NODE_ATTRIBUTE (NODE, ATTRIBUTE, VALUE);
 CLOSE (NODE);
exception
 when others =>
     CLOSE (NODE);
     raise;
end SET_NODE_ATTRIBUTE;


procedure SET_PATH_ATTRIBUTE
       (BASE       : NODE_TYPE;
        KEY        : RELATIONSHIP_KEY;
        RELATION   : RELATION_NAME :=
                     DEFAULT_RELATION;
        ATTRIBUTE  : ATTRIBUTE_NAME;
        VALUE      : LIST_TYPE) is separate;

procedure SET_PATH_ATTRIBUTE(NAME      : NAME_STRING;
                   ATTRIBUTE : ATTRIBUTE_NAME;
                   VALUE     : LIST_TYPE) is
 BASE : NODE_TYPE;
begin
 OPEN (BASE, BASE_PATH (NAME),
       (1 => WRITE_RELATIONSHIPS));
 SET_PATH_ATTRIBUTE
    (BASE, LAST_KEY (NAME), LAST_RELATION (NAME),
     ATTRIBUTE, VALUE);
 CLOSE (BASE);
exception
 when others =>
     CLOSE (BASE);
     raise;
end SET_PATH_ATTRIBUTE;
```

```
procedure GET_NODE_ATTRIBUTE
       (NODE      : NODE_TYPE;
        ATTRIBUTE : ATTRIBUTE_NAME;
        VALUE     : in out LIST_TYPE) is separate;

procedure GET_NODE_ATTRIBUTE
       (NAME      : NAME_STRING;
        ATTRIBUTE : ATTRIBUTE_NAME;
        VALUE     : in out LIST_TYPE) is
 NODE : NODE_TYPE;
begin
 OPEN (NODE, NAME, (1 => READ_RELATIONSHIPS));
 GET_NODE_ATTRIBUTE (NODE, ATTRIBUTE, VALUE);
 CLOSE (NODE);
exception
 when others =>
     CLOSE (NODE);
     raise;
end GET_NODE_ATTRIBUTE;


procedure GET_PATH_ATTRIBUTE
       (BASE      : NODE_TYPE;
        KEY       : RELATIONSHIP_KEY;
        RELATION  : RELATION_NAME :=
                 DEFAULT_RELATION;
        ATTRIBUTE : ATTRIBUTE_NAME;
        VALUE     : in out LIST_TYPE) is separate;

procedure GET_PATH_ATTRIBUTE
       (NAME      : NAME_STRING;
        ATTRIBUTE : ATTRIBUTE_NAME;
        VALUE     : in out LIST_TYPE) is
 BASE : NODE_TYPE;
begin
 OPEN (BASE, BASE_PATH (NAME), (1 => READ_RELATIONSHIPS));
 GET_PATH_ATTRIBUTE
    (BASE, LAST_KEY (NAME), LAST_RELATION (NAME),
     ATTRIBUTE, VALUE);
 CLOSE (BASE);
exception
 when others =>
     CLOSE (BASE);
     raise;
end GET_PATH_ATTRIBUTE;


procedure NODE_ATTRIBUTE_ITERATE
       (ITERATOR : out ATTRIBUTE_ITERATOR;
        NODE     : NODE_TYPE;
        PATTERN  : ATTRIBUTE_PATTERN := "*") is separate;

procedure NODE_ATTRIBUTE_ITERATE
       (ITERATOR : out ATTRIBUTE_ITERATOR;
        NAME     : NAME_STRING;
        PATTERN  : ATTRIBUTE_PATTERN := "*") is
 NODE : NODE_TYPE;
begin
 OPEN (NODE, NAME, (1 => READ_ATTRIBUTES));
 NODE_ATTRIBUTE_ITERATE (ITERATOR, NODE, PATTERN);
 CLOSE (NODE);
exception
 when others =>
     CLOSE (NODE);
     raise;
```

```
    end NODE_ATTRIBUTE_ITERATE;


    procedure PATH_ATTRIBUTE_ITERATE
           (ITERATOR : in out ATTRIBUTE_ITERATOR;
            BASE     : NODE_TYPE;
            KEY      : RELATIONSHIP_KEY;
            RELATION : RELATION_NAME :=
                    DEFAULT_RELATION;
            PATTERN  : ATTRIBUTE_PATTERN := "*") is separate;

    procedure PATH_ATTRIBUTE_ITERATE
           (ITERATOR : in out ATTRIBUTE_ITERATOR;
            NAME     : NAME_STRING;
            PATTERN  : ATTRIBUTE_PATTERN := "*") is
     BASE : NODE_TYPE;
    begin
     OPEN (BASE, BASE_PATH (NAME),
           (1 => WRITE_RELATIONSHIPS));
     PATH_ATTRIBUTE_ITERATE
        (ITERATOR, BASE, LAST_KEY (NAME),
         LAST_RELATION (NAME), PATTERN);
     CLOSE (BASE);
    exception
     when others =>
         CLOSE (BASE);
         raise;
    end PATH_ATTRIBUTE_ITERATE;


    function MORE (ITERATOR : ATTRIBUTE_ITERATOR)
             return BOOLEAN
    is
       RESULT : BOOLEAN;
    begin
       -- should be defined by implementor
       return RESULT;
    end MORE;

    procedure GET_NEXT(ITERATOR  : in out ATTRIBUTE_ITERATOR;
              ATTRIBUTE : out ATTRIBUTE_NAME;
              VALUE     : in out LIST_TYPE)
    is
    begin
       null;  -- should be defined by implementor
    end GET_NEXT;

end ATTRIBUTES;

separate (CAIS)
package body ACCESS_CONTROL is
    use NODE_DEFINITIONS;
    use NODE_MANAGEMENT;

    procedure SET_ACCESS_CONTROL
           (NODE      : NODE_TYPE;
            ROLE_NODE : NODE_TYPE;
            GRANT     : GRANT_VALUE) is separate;

    procedure SET_ACCESS_CONTROL
           (NAME      : NAME_STRING;
            ROLE_NAME : NAME_STRING;
            GRANT     : GRANT_VALUE) is
     NODE, ROLE_NODE : NODE_TYPE;
```

```
    begin
     OPEN (NODE, NAME, (1 => CONTROL));
     OPEN (ROLE_NODE, ROLE_NAME, (1 => EXISTENCE));
     SET_ACCESS_CONTROL (NODE, ROLE_NODE, GRANT);
     CLOSE (NODE);
     CLOSE (ROLE_NODE);
    exception
     when others =>
         CLOSE (NODE);
         CLOSE (ROLE_NODE);
         raise;
    end SET_ACCESS_CONTROL;


    function IS_GRANTED (OBJECT_NODE   : NODE_TYPE;
                         ACCESS_RIGHT : NAME_STRING)
             return BOOLEAN is separate;

    function IS_GRANTED (OBJECT_NAME   : NAME_STRING;
                         ACCESS_RIGHT : NAME_STRING)
             return BOOLEAN is
     OBJECT_NODE : NODE_TYPE;
     RESULT      : BOOLEAN;
    begin
     OPEN (OBJECT_NODE, OBJECT_NAME,
           (1 => READ_RELATIONSHIPS));
     RESULT := IS_GRANTED (OBJECT_NODE, ACCESS_RIGHT);
     CLOSE (OBJECT_NODE);
     return RESULT;
    exception
     when others =>
         CLOSE (OBJECT_NODE);
         raise;
    end IS_GRANTED;


    procedure ADOPT (ROLE_NODE : NODE_TYPE) is separate;
                     ROLE_KEY : RELATIONSHIP_KEY := LATEST_KEY)
                     is separate;

    procedure UNADOPT(ROLE_KEY : RELATIONSHIP_KEY) is separate;
end ACCESS_CONTROL;

separate (CAIS)
package body STRUCTURAL_NODES is
    use NODE_DEFINITIONS;
    use NODE_MANAGEMENT;

    procedure CREATE_NODE
           (NODE            : in out NODE_TYPE;
            BASE            : NODE_TYPE;
            KEY             : RELATIONSHIP_KEY :=
                      LATEST_KEY;
            RELATION        : RELATION_NAME :=
                      DEFAULT_RELATION;
            ATTRIBUTES      : LIST_TYPE := EMPTY_LIST;
            ACCESS_CONTROL  : LIST_TYPE := EMPTY_LIST;
            LEVEL           : LIST_TYPE := EMPTY_LIST) is separate;

    procedure CREATE_NODE
           (NODE            : in out NODE_TYPE;
            NAME            : NAME_STRING;
            ATTRIBUTES      : LIST_TYPE := EMPTY_LIST;
            ACCESS_CONTROL  : LIST_TYPE := EMPTY_LIST;
            LEVEL           : LIST_TYPE := EMPTY_LIST) is
```

```
    BASE : NODE_TYPE;
   begin
    OPEN (BASE, BASE_PATH (NAME),
          (1 => APPEND_RELATIONSHIPS));
    CREATE_NODE
       (NODE, BASE, LAST_KEY (NAME), LAST_RELATION (NAME),
        ATTRIBUTES, ACCESS_CONTROL, LEVEL);
    CLOSE (BASE);
   exception
    when others =>
        CLOSE (NODE);
        CLOSE (BASE);
        raise;
   end CREATE_NODE;


   procedure CREATE_NODE
          (BASE            : NODE_TYPE;
           KEY             : RELATIONSHIP_KEY :=
                             LATEST_KEY;
           RELATION        : RELATION_NAME :=
                             DEFAULT_RELATION;
           ATTRIBUTES      : LIST_TYPE := EMPTY_LIST;
           ACCESS_CONTROL  : LIST_TYPE := EMPTY_LIST;
           LEVEL           : LIST_TYPE := EMPTY_LIST) is
    NODE : NODE_TYPE;
   begin
    CREATE_NODE
       (NODE, KEY, RELATION, ATTRIBUTES, ACCESS_CONTROL,
        LEVEL);
    CLOSE (NODE);
   end CREATE_NODE;


   procedure CREATE_NODE
          (NAME            : NAME_STRING;
           ATTRIBUTES      : LIST_TYPE := EMPTY_LIST;
           ACCESS_CONTROL  : LIST_TYPE := EMPTY_LIST;
           LEVEL           : LIST_TYPE := EMPTY_LIST) is
    NODE : NODE_TYPE;
   begin
    CREATE_NODE
       (NODE, NAME, ATTRIBUTES, ACCESS_CONTROL, LEVEL);
    CLOSE (NODE);
   end CREATE_NODE;
end STRUCTURAL_NODES;

separate (CAIS)
package body PROCESS_CONTROL is
   use NODE_DEFINITIONS;
   use PROCESS_DEFINITIONS;
   use NODE_MANAGEMENT;
   use LIST_UTILITIES;

   procedure SPAWN_PROCESS
          (NODE              : in out NODE_TYPE;
           FILE_NODE         : NODE_TYPE;
           INPUT_PARAMETERS  : PARAMETER_LIST := "";
           KEY               : RELATIONSHIP_KEY :=
                               LATEST_KEY;
           RELATION          : RELATION_NAME :=
                               DEFAULT_RELATION;
           ACCESS_CONTROL    : LIST_TYPE := EMPTY_LIST;
           LEVEL             : LIST_TYPE := EMPTY_LIST;
           ATTRIBUTES        : LIST_TYPE := EMPTY_LIST;
```

```
        INPUT_FILE          : NAME_STRING :=
                              CURRENT_INPUT;
        OUTPUT_FILE         : NAME_STRING :=
                              CURRENT_OUTPUT;
        ERROR_FILE          : NAME_STRING :=
                              CURRENT_ERROR;

        ENVIRONMENT_NODE : NAME_STRING :=
                              CURRENT_NODE) is separate;

    procedure AWAIT_PROCESS_COMPLETION
        (NODE               : NODE_TYPE;
         TIME_LIMIT         : DURATION := DURATION'LAST)
                                            is separate;

    procedure AWAIT_PROCESS_COMPLETION
        (NODE               : NODE_TYPE;
         RESULTS_RETURNED : in out RESULTS_LIST;
         STATUS             : out PROCESS_STATUS;
         TIME_LIMIT         : DURATION :=
                              DURATION'LAST) is
begin
    AWAIT_PROCESS_COMPLETION (NODE, TIME_LIMIT);
    GET_RESULTS (NODE, RESULTS_RETURNED);
    STATUS := STATE_OF_PROCESS (NODE);
end AWAIT_PROCESS_COMPLETION;

    procedure INVOKE_PROCESS
        (NODE               : in out NODE_TYPE;
         FILE_NODE          : NODE_TYPE;
         RESULTS_RETURNED : in out RESULTS_LIST;
         STATUS             : out PROCESS_STATUS;
         INPUT_PARAMETERS : PARAMETER_LIST := "";
         KEY                : RELATIONSHIP_KEY :=
                              LATEST_KEY;
         RELATION           : RELATION_NAME :=
                              DEFAULT_RELATION;
         ACCESS_CONTROL     : LIST_TYPE := EMPTY_LIST;
         LEVEL              : LIST_TYPE := EMPTY_LIST;
         ATTRIBUTES         : LIST_TYPE := EMPTY_LIST;
         INPUT_FILE         : NAME_STRING :=
                              CURRENT_INPUT;
         OUTPUT_FILE        : NAME_STRING :=
                              CURRENT_OUTPUT;
         ERROR_FILE         : NAME_STRING :=
                              CURRENT_ERROR;
         ENVIRONMENT_NODE : NAME_STRING :=
                              CURRENT_NODE;
         TIME_LIMIT         : DURATION :=
                              DURATION'LAST) is separate;

    procedure CREATE_JOB
        (FILE_NODE          : NODE_TYPE;
         INPUT_PARAMETERS : PARAMETER_LIST;
         KEY                : RELATIONSHIP_KEY :=
                              LATEST_KEY;
         ACCESS_CONTROL     : LIST_TYPE := EMPTY_LIST;
         LEVEL              : LIST_TYPE := EMPTY_LIST;
         ATTRIBUTES         : LIST_TYPE := EMPTY_LIST;
         INPUT_FILE         : NAME_STRING :=
                              CURRENT_INPUT;
         OUTPUT_FILE        : NAME_STRING :=
                              CURRENT_OUTPUT;
         ERROR_FILE         : NAME_STRING :=
                              CURRENT_ERROR;
```

```
        ENVIRONMENT_NODE : NAME_STRING := CURRENT_USER)
                                       is separate;

procedure APPEND_RESULTS(RESULTS : RESULTS_STRING)
                                       is separate;

procedure WRITE_RESULTS(RESULTS : RESULTS_STRING) is separate;

procedure GET_RESULTS(NODE    : NODE_TYPE;
             RESULTS : in out RESULTS_LIST) is separate;

procedure GET_RESULTS (NODE    : NODE_TYPE;
             RESULTS : in out RESULTS_LIST;
             STATUS  : out PROCESS_STATUS) is
begin
 GET_RESULTS (NODE, RESULTS);
 STATUS := STATE_OF_PROCESS (NODE);
end GET_RESULTS;


procedure GET_RESULTS(NAME    : NAME_STRING;
             RESULTS : in out RESULTS_LIST;
             STATUS  : out PROCESS_STATUS) is
 NODE : NODE_TYPE;
begin
 OPEN (NODE, NAME, (1 => READ_ATTRIBUTES));
 GET_RESULTS (NODE, RESULTS);
 STATUS := STATE_OF_PROCESS (NODE);
 CLOSE (NODE);
exception
 when others =>
     CLOSE (NODE);
     raise;
end GET_RESULTS;


procedure GET_RESULTS(NAME    : NAME_STRING;
             RESULTS : in out RESULTS_LIST) is
 NODE   : NODE_TYPE;
begin
 OPEN (NODE, NAME, (1 => READ_ATTRIBUTES));
 GET_RESULTS (NODE, RESULTS);
 CLOSE (NODE);
exception
 when others =>
     CLOSE (NODE);
     raise;
end GET_RESULTS;


procedure GET_PARAMETERS
       (PARAMETERS : in out PARAMETER_LIST) is separate;

procedure ABORT_PROCESS(NODE    : NODE_TYPE;
               RESULTS : RESULTS_STRING) is separate;

procedure ABORT_PROCESS(NAME    : NAME_STRING;
               RESULTS : RESULTS_STRING) is
 NODE : NODE_TYPE;
begin
 OPEN (NODE, NAME, (READ_RELATIONSHIPS,WRITE_CONTENTS,WRITE_ATTRIBUTES));
 ABORT_PROCESS (NODE, RESULTS);
 CLOSE (NODE);
exception
 when others =>
```

```
    CLOSE (NODE);
    raise;
end ABORT_PROCESS;


procedure ABORT_PROCESS(NODE : NODE_TYPE) is
begin
 ABORT_PROCESS (NODE, "ABORTED");
end ABORT_PROCESS;


procedure ABORT_PROCESS(NAME : NAME_STRING) is
 NODE : NODE_TYPE;
begin
 OPEN (NODE, NAME, READ_RELATIONSHIPS,WRITE_CONTENTS,WRITE_ATTRIBUTES));
 ABORT_PROCESS (NODE, "ABORTED");
 CLOSE (NODE);
exception
 when others =>
    CLOSE (NODE);
    raise;
end ABORT_PROCESS;


procedure SUSPEND_PROCESS(NODE : NODE_TYPE) is separate;

procedure SUSPEND_PROCESS(NAME : NAME_STRING) is
 NODE : NODE_TYPE;
begin
 OPEN (NODE, NAME, READ_RELATIONSHIPS,WRITE_CONTENTS,WRITE_ATTRIBUTES));
 SUSPEND_PROCESS (NODE);
 CLOSE (NODE);
exception
 when others =>
    CLOSE (NODE);
    raise;
end SUSPEND_PROCESS;


procedure RESUME_PROCESS(NODE : NODE_TYPE) is separate;

procedure RESUME_PROCESS(NAME : NAME_STRING) is
 NODE : NODE_TYPE;
begin
 OPEN (NODE, NAME, READ_RELATIONSHIPS,WRITE_ATTRIBUTES,WRITE_CONTENTS));
 RESUME_PROCESS (NODE);
 CLOSE (NODE);
exception
 when others =>
    CLOSE (NODE);
    raise;
end RESUME_PROCESS;


function STATUS_OF_PROCESS(NODE : NODE_TYPE)
         return PROCESS_STATUS is separate;


function STATUS_OF_PROCESS(NAME : NAME_STRING)
         return PROCESS_STATUS is
 NODE   : NODE_TYPE;
 RESULT : PROCESS_STATUS;
begin
 OPEN (NODE, NAME, (1 => READ_ATTRIBUTES));
 RESULT := STATE_OF_PROCESS (NODE);
```

```
 CLOSE (NODE);
 return RESULT;
exception
 when others =>
     CLOSE (NODE);
     raise;
end STATUS_OF_PROCESS;


function HANDLES_OPEN(NODE : NODE_TYPE) return NATURAL
                                                is separate;

function HANDLES_OPEN(NAME : NAME_STRING) return NATURAL is
 NODE   : NODE_TYPE;
 RESULT : NATURAL;
begin
 OPEN (NODE, NAME, (1 => READ_ATTRIBUTES));
 RESULT := HANDLES_OPEN (NODE);
 CLOSE (NODE);
 return RESULT;
exception
 when others =>
     CLOSE (NODE);
     raise;
end HANDLES_OPEN;


function IO_UNITS(NODE : NODE_TYPE) return NATURAL is separate;

function IO_UNITS(NAME : NAME_STRING) return NATURAL is
 NODE   : NODE_TYPE;
 RESULT : NATURAL;
begin
 OPEN (NODE, NAME, (1 => READ_ATTRIBUTES));
 RESULT := IO_UNITS (NODE);
 CLOSE (NODE);
 return RESULT;
exception
 when others =>
     CLOSE (NODE);
     raise;
end IO_UNITS;


function START_TIME(NODE : NODE_TYPE)
          return TIME is separate;

function START_TIME(NAME : NAME_STRING)
          return TIME is
 NODE   : NODE_TYPE;
 RESULT : TIME;
begin
 OPEN (NODE, NAME, (1 => READ_ATTRIBUTES));
 RESULT := START_TIME (NODE);
 CLOSE (NODE);
 return RESULT;
exception
 when others =>
     CLOSE (NODE);
     raise;
end START_TIME;


function FINISH_TIME(NODE : NODE_TYPE)
          return TIME is separate;
```

```
    function FINISH_TIME(NAME : NAME_STRING)
             return TIME is
     NODE   : NODE_TYPE;
     RESULT : TIME;
    begin
     OPEN (NODE, NAME, (1 => READ_ATTRIBUTES));
     RESULT := FINISH_TIME (NODE);
     CLOSE (NODE);
     return RESULT;
    exception
     when others =>
         CLOSE (NODE);
         raise;
    end FINISH_TIME;


    function MACHINE_TIME(NODE : NODE_TYPE) return DURATION
                                        is separate;

    function MACHINE_TIME(NAME : NAME_STRING) return DURATION is
     NODE   : NODE_TYPE;
     RESULT : DURATION;
    begin
     OPEN (NODE, NAME, (1 => READ_ATTRIBUTES));
     RESULT := MACHINE_TIME (NODE);
     CLOSE (NODE);
     return RESULT;
    exception
     when others =>
         CLOSE (NODE);
         raise;
    end MACHINE_TIME;


end PROCESS_CONTROL;

separate (CAIS)
package body IO_CONTROL is
    use NODE_DEFINITIONS;
    use NODE_MANAGEMENT;
    use IO_DEFINITIONS;
    use LIST_UTILITIES;

    procedure OPEN_FILE_NODE(FILE        : FILE_TYPE;
                             NODE        : in out NODE_TYPE;
                             INTENT      : INTENTION;
                             TIME_LIMIT  : DURATION := NO_DELAY)
                                          is separate;

    procedure SYNCHRONIZE(FILE : FILE_TYPE) is separate;

    procedure SET_LOG(FILE     : FILE_TYPE;
                      LOG_FILE : FILE_TYPE) is separate;

    procedure CLEAR_LOG(FILE : FILE_TYPE) is separate;

    function LOGGING(FILE : FILE_TYPE) return BOOLEAN is separate;

    function GET_LOG(FILE : FILE_TYPE) return FILE_TYPE is separate;

    function NUMBER_OF_ELEMENTS(FILE : FILE_TYPE) return NATURAL
    is
       RESULT : NATURAL;
    begin
```

```
      -- should be defined by implementor;
      return RESULT;
   end NUMBER_OF_ELEMENTS;

   procedure SET_PROMPT(TERMINAL : FILE_TYPE;
                        PROMPT   : STRING) is separate;

   function GET_PROMPT(TERMINAL : FILE_TYPE) return STRING
                                                is separate;

   function INTERCEPTED_CHARACTERS(TERMINAL : FILE_TYPE)
            return CHARACTER_ARRAY is separate;

   procedure ENABLE_FUNCTION_KEYS(TERMINAL : FILE_TYPE;
                                  ENABLE   : BOOLEAN)
                                                is separate;

   function FUNCTION_KEYS_ENABLED(TERMINAL : FILE_TYPE)
                                  return BOOLEAN is separate;

   procedure COUPLE
          (QUEUE_BASE      : NODE_TYPE;
           QUEUE_KEY       : RELATIONSHIP_KEY :=
                             LATEST_KEY;
           QUEUE_RELATION  : RELATION_NAME :=
                             DEFAULT_RELATION;
           FILE_NODE       : NODE_TYPE;
           FORM            : LIST_TYPE := EMPTY_LIST;
           ATTRIBUTES      : LIST_TYPE; -- intentionally
                               -- not
                               -- defaulted
                               --
           ACCESS_CONTROL  : LIST_TYPE := EMPTY_LIST;
           LEVEL           : LIST_TYPE := EMPTY_LIST) is separate;

   procedure COUPLE
          (QUEUE_NAME      : NAME_STRING;
           FILE_NODE       : NODE_TYPE;
           FORM            : LIST_TYPE := EMPTY_LIST;
           ATTRIBUTES      : LIST_TYPE;
           ACCESS_CONTROL  : LIST_TYPE := EMPTY_LIST;
           LEVEL           : LIST_TYPE := EMPTY_LIST) 's
    BASE : NODE_TYPE;
   begin
    OPEN (BASE, BASE_PATH (QUEUE_NAME),
          (1 => APPEND_RELATIONSHIPS));
    COUPLE
       (BASE, LAST_KEY (QUEUE_NAME),
        LAST_RELATION (QUEUE_NAME), FILE_NODE, FORM,
        ATTRIBUTES, ACCESS_CONTROL, LEVEL);
    CLOSE (BASE);
   exception
    when others =>
        CLOSE (BASE);
    raise;
   end COUPLE;


   procedure COUPLE
          (QUEUE_BASE      : NODE_TYPE;
           QUEUE_KEY       : RELATIONSHIP_KEY :=
                             LATEST_KEY;
           QUEUE_RELATION  : RELATION_NAME :=
                             DEFAULT_RELATION;
           FILE_NAME       : NAME_STRING;
```

```
            FORM           : LIST_TYPE := EMPTY_LIST;
            ATTRIBUTES     : LIST_TYPE;
            ACCESS_CONTROL : LIST_TYPE := EMPTY_LIST;
            LEVEL          : LIST_TYPE := EMPTY_LIST) is
     FILE_NODE : NODE_TYPE;
    begin
     OPEN (FILE_NODE, FILE_NAME, (READ_ATTRIBUTES, READ_CONTENTS));
     COUPLE
        (QUEUE_BASE, QUEUE_KEY, QUEUE_RELATION, FILE_NODE,
         FORM, ATTRIBUTES, ACCESS_CONTROL, LEVEL);
     CLOSE (FILE_NODE);
    exception
     when others =>
         CLOSE (FILE_NODE);
    raise;
    end COUPLE;


    procedure COUPLE
           (QUEUE_NAME     : NAME_STRING;
            FILE_NAME      : NAME_STRING;
            FORM           : LIST_TYPE := EMPTY_LIST;
            ATTRIBUTES     : LIST_TYPE;
            ACCESS_CONTROL : LIST_TYPE := EMPTY_LIST;
            LEVEL          : LIST_TYPE := EMPTY_LIST) is
     FILE_NODE  : NODE_TYPE;
     QUEUE_BASE : NODE_TYPE;
    begin
     OPEN (QUEUE_BASE, BASE_PATH (QUEUE_NAME),
           (1 => APPEND_RELATIONSHIPS));
     OPEN (FILE_NODE, FILE_NAME, (READ_ATTRIBUTES, READ_CONTENTS));
     COUPLE
        (QUEUE_BASE, LAST_KEY (QUEUE_NAME),
         LAST_RELATION (QUEUE_NAME), FILE_NODE, FORM,
         ATTRIBUTES, ACCESS_CONTROL, LEVEL);
     CLOSE (QUEUE_BASE);
     CLOSE (FILE_NODE);
    exception
     when others =>
         CLOSE (QUEUE_BASE);
         CLOSE (FILE_NODE);
    raise;
    end COUPLE;

end IO_CONTROL;


separate (CAIS)
package body DIRECT_IO is
    use NODE_DEFINITIONS;
    use IO_DEFINITIONS;
    use NODE_MANAGEMENT;



    -- File management


    procedure CREATE(FILE           : in out FILE_TYPE;
                     BASE           : NODE_TYPE;
                     KEY            : RELATIONSHIP_KEY :=
                                      LATEST_KEY;
                     RELATION       : RELATION_NAME :=
                                      DEFAULT_RELATION;
                     MODE           : FILE_MODE :=
```

```
                           INOUT_FILE;
             FORM        : LIST_TYPE :=
                           EMPTY_LIST;
             ATTRIBUTES  : LIST_TYPE :=
                           EMPTY_LIST;
             ACCESS_CONTROL : LIST_TYPE := EMPTY_LIST;
             LEVEL       : LIST_TYPE := EMPTY_LIST)
is
begin
   null; -- should be defined by implementor
end CREATE;

procedure CREATE(FILE          : in out FILE_TYPE;
             NAME           : NAME_STRING;
             MODE           : FILE_MODE :=
                              INOUT_FILE;
             FORM           : LIST_TYPE :=
                              EMPTY_LIST;
             ATTRIBUTES     : LIST_TYPE :=
                              EMPTY_LIST;
             ACCESS_CONTROL : LIST_TYPE := EMPTY_LIST;
             LEVEL          : LIST_TYPE := EMPTY_LIST) is
 BASE : NODE_TYPE;
begin
 OPEN (BASE, BASE_PATH (NAME),
       (1 => APPEND_RELATIONSHIPS));
 CREATE (FILE, BASE, LAST_KEY (NAME),
      LAST_RELATION (NAME), MODE, FORM, ATTRIBUTES,
      ACCESS_CONTROL, LEVEL);
 CLOSE (BASE);
exception
 when others =>
     CLOSE (FILE);
     CLOSE (BASE);
     raise;
end CREATE;


procedure OPEN(FILE : in out FILE_TYPE;
           NODE : NODE_TYPE;
           MODE : FILE_MODE)
is
begin
   null; -- should be defined by implementor
end OPEN;

procedure OPEN(FILE : in out FILE_TYPE;
           NAME : NAME_STRING;
           MODE : FILE_MODE) is
 NODE : NODE_TYPE;
begin
 case MODE is
     when IN_FILE     => OPEN (NODE, NAME,
                         (1 => READ_CONTENTS));
     when OUT_FILE    => OPEN (NODE, NAME,
                         (1 => WRITE_CONTENTS));
     when INOUT_FILE  => OPEN (NODE, NAME,
                         (READ_CONTENTS, WRITE_CONTENTS));
     when APPEND_FILE => raise USE_ERROR;
 end case;

 OPEN (FILE, NODE, MODE);
 CLOSE (NODE);
exception
 when others =>
```

```
     CLOSE (FILE);
     CLOSE (NODE);
     raise;
end OPEN;

procedure CLOSE(FILE : in out FILE_TYPE)
is
begin
   null;  -- should be defined by implementor
end CLOSE;

procedure DELETE(FILE : in out FILE_TYPE)
is
begin
   null; -- should be defined by implementor
end DELETE;

procedure RESET(FILE : in out FILE_TYPE;
           MODE : FILE_MODE) is
begin
 null; -- should be defined by implementor
end RESET;

procedure RESET(FILE : in out FILE_TYPE) is
begin
 null; -- should be defined by implementor
end RESET;

function MODE(FILE : FILE_TYPE) return FILE_MODE
is
   RESULT : FILE_MODE;
begin
   -- should be defined by implementor
   return RESULT;
end MODE;

function NAME(FILE : FILE_TYPE) return STRING is separate;

function FORM(FILE : FILE_TYPE) return STRING
is
   RESULT : STRING( 1 .. 10);
begin
   -- should be defined by implementor
   return RESULT;
end FORM;

function IS_OPEN(FILE : FILE_TYPE) return BOOLEAN
is
   RESULT : BOOLEAN;
begin
   -- should be defined by implementor
   return RESULT;
end IS_OPEN;

-- Input and output operations

procedure READ(FILE : FILE_TYPE;
          ITEM : out ELEMENT_TYPE;
          FROM : POSITIVE_COUNT) is
begin
 null; -- should be defined by implementor
end READ;

procedure READ (FILE : FILE_TYPE;
```

```
                ITEM : out ELEMENT_TYPE) is
    begin
     null; -- should be defined by implementor
    end READ;

    procedure WRITE(FILE : FILE_TYPE;
                    ITEM : ELEMENT_TYPE;
                    TO   : POSITIVE_COUNT) is
    begin
     null; -- should be defined by implementor
    end WRITE;

    procedure WRITE(FILE : FILE_TYPE;
                    ITEM : ELEMENT_TYPE) is
    begin
     null; -- should be defined by implementor
    end WRITE;

    procedure SET_INDEX(FILE : FILE_TYPE;
                        TO   : POSITIVE_COUNT) is separate;

    function INDEX(FILE : FILE_TYPE) return POSITIVE_COUNT is separate;

    function SIZE(FILE : FILE_TYPE) return COUNT
                                    is separate;

    function END_OF_FILE(FILE : FILE_TYPE) return BOOLEAN
    is
       RESULT : BOOLEAN;
    begin
       -- should be defined by implementor
       return RESULT;
    end END_OF_FILE;
end DIRECT_IO;

separate (CAIS)
package body SEQUENTIAL_IO is
    use NODE_DEFINITIONS;
    use NODE_MANAGEMENT;
    use DEFINITIONS;


    -- File management


    procedure CREATE(FILE           : in out FILE_TYPE;
                     BASE           : NODE_TYPE;
                     KEY            : RELATIONSHIP_KEY :=
                                      LATEST_KEY;
                     RELATION       : RELATION_NAME :=
                                      DEFAULT_RELATION;
                     MODE           : FILE_MODE :=
                                      INOUT_FILE;
                     FORM           : LIST_TYPE :=
                                      EMPTY_LIST;
                     ATTRIBUTES     : LIST_TYPE :=
                                      EMPTY_LIST;
                     ACCESS_CONTROL : LIST_TYPE := EMPTY_LIST;
                     LEVEL          : LIST_TYPE := EMPTY_LIST)
    is
    begin
       null; -- should be defined by implementor
    end CREATE;
```

```
procedure CREATE(FILE          : in out FILE_TYPE;
         NAME           : NAME_STRING;
         MODE           : FILE_MODE :=
                          INOUT_FILE;
         FORM           : LIST_TYPE :=
                          EMPTY_LIST;
         ATTRIBUTES     : LIST_TYPE :=
                          EMPTY_LIST;
         ACCESS_CONTROL : LIST_TYPE := EMPTY_LIST;
         LEVEL          : LIST_TYPE := EMPTY_LIST) is
 BASE : NODE_TYPE;
begin
 OPEN (BASE, BASE_PATH (NAME),
       (1 => APPEND_RELATIONSHIPS));
 CREATE (FILE, BASE, LAST_KEY (NAME),
      LAST_RELATION (NAME), MODE, FORM, ATTRIBUTES,
      ACCESS_CONTROL, LEVEL);
 CLOSE (BASE);
exception
 when others =>
     CLOSE (FILE);
     CLOSE (BASE);
     raise;
end CREATE;


procedure OPEN(FILE : in out FILE_TYPE;
          NODE : NODE_TYPE;
          MODE : FILE_MODE) is
begin
 null; -- should be defined by implementor
end OPEN;

procedure OPEN(FILE : in out FILE_TYPE;
          NAME : NAME_STRING;
          MODE : FILE_MODE)
is
          NODE : NODE_TYPE
begin
case MODE is
 when IN_FILE => OPEN (NODE, NAME, (1 => READ_CONTENTS));
 when OUT_FILE => OPEN (NODE, NAME, (1 => WRITE_CONTENTS));
 when INOUT_FILE => OPEN (NODE, NAME,
                       (READ_CONTENTS, WRITE_CONTENTS));
 when APPEND_FILE => OPEN (NODE, NAME, (1=> APPEND_CONTENTS));
end case;

OPEN (FILE, NODE, MODE);
CLOSE (NODE);
exception
when others =>
  CLOSE (FILE);
  CLOSE (NODE);
  raise;
end OPEN;

procedure CLOSE(FILE : in out FILE_TYPE)
is
begin
  null;  -- should be defined by implementor
end CLOSE;


procedure DELETE(FILE : in out FILE_TYPE)
```

```
    is
    begin
       null;-- should be defined by implementor
    end DELETE;

    procedure RESET(FILE : in out FILE_TYPE;
                    MODE : FILE_MODE) is
    begin
     null; -- should be defined by implementor
    end RESET;

    procedure RESET(FILE : in out FILE_TYPE) is
    begin
     null; -- should be defined by implementor
    end REPLACE;

    function MODE(FILE : FILE_TYPE) return FILE_MODE
    is
       RESULT : FILE_MODE;
    begin
       -- should be defined by implementor
       return RESULT;
    end MODE;

    function NAME(FILE : FILE_TYPE) return STRING
    is
       RESULT : STRING(1..10);
    begin
       -- should be defined by implementor
       return RESULT;
    end NAME;

    function FORM(FILE : FILE_TYPE) return STRING
    is
       RESULT : STRING(1..10);
    begin
       -- should be defined by implementor
       return RESULT;
    end FORM;

    function IS_OPEN(FILE : FILE_TYPE) return BOOLEAN
    is
       RESULT : BOOLEAN;
    begin
       -- should be defined by implementor
       return RESULT;
    end IS_OPEN;

    -- Input and output operations

    procedure READ(FILE : FILE_TYPE;
                   ITEM : out ELEMENT_TYPE) is separate;

    procedure WRITE(FILE : FILE_TYPE; ITEM : ELEMENT_TYPE) is separa
te;

    function END_OF_FILE(FILE : FILE_TYPE) return BOOLEAN
    is
       RESULT : BOOLEAN;
    begin
       -- should be defined by implementor
       return RESULT;
    end END_OF_FILE;
end SEQUENTIAL_IO;
```

```
separate (CAIS)
package body TEXT_IO is
    use NODE_DEFINITIONS;
    use NODE_MANAGEMENT;
    use IO_DEFINITIONS;
    use LIST_UTILITIES;

    -- File Management


    procedure CREATE(FILE             : in out FILE_TYPE;
                 BASE             : NODE_TYPE;
                 KEY              : RELATIONSHIP_KEY :=
                                    LATEST_KEY;
                 RELATION         : RELATION_NAME :=
                                    DEFAULT_RELATION;
                 MODE             : FILE_MODE :=
                                    INOUT_FILE;
                 FORM             : LIST_TYPE :=
                                    EMPTY_LIST;
                 ATTRIBUTES       : LIST_TYPE :=
                                    EMPTY_LIST;
                 ACCESS_CONTROL   : LIST_TYPE := EMPTY_LIST;
                 LEVEL            : LIST_TYPE := EMPTY_LIST) is separate;

    procedure CREATE(FILE             : in out FILE_TYPE;
                 NAME             : NAME_STRING;
                 MODE             : FILE_MODE :=
                                    INOUT_FILE;
                 FORM             : LIST_TYPE :=
                                    EMPTY_LIST;
                 ATTRIBUTES       : LIST_TYPE :=
                                    EMPTY_LIST;
                 ACCESS_CONTROL   : LIST_TYPE := EMPTY_LIST;
                 LEVEL            : LIST_TYPE := EMPTY_LIST) is
     BASE : NODE_TYPE;
    begin
     OPEN (BASE, BASE_PATH (NAME),
           (1 => APPEND_RELATIONSHIPS));
     CREATE (FILE, BASE, LAST_KEY (NAME),
          LAST_RELATION (NAME), MODE, FORM, ATTRIBUTES,
          ACCESS_CONTROL, LEVEL);
     CLOSE (BASE);
    exception
     when others =>
         CLOSE (FILE);
         CLOSE (BASE);
    raise;
    end CREATE;


    procedure OPEN(FILE : in out FILE_TYPE;
               NODE : NODE_TYPE;
               MODE : FILE_MODE) is separate;

    procedure OPEN(FILE : in out FILE_TYPE;
               NAME : NAME_STRING;
               MODE : FILE_MODE) is
     NODE : NODE_TYPE;
    begin
     case MODE is
         when IN_FILE =>  OPEN (NODE, NAME,
                          (1 => READ_CONTENTS));

         when OUT_FILE =>  OPEN (NODE, NAME,
```

```
                              (1 => WRITE_CONTENTS));

          when INOUT_FILE =>
           OPEN (NODE, NAME,
                 (READ_CONTENTS, WRITE_CONTENTS));

          when APPEND_FILE =>  OPEN (NODE, NAME,
                                (1 => APPEND_CONTENTS));
     end case;

     OPEN (FILE, NODE, MODE);
     CLOSE (NODE);
    exception
     when others =>
         CLOSE (FILE);
         CLOSE (NODE);
    raise
    end OPEN;

    procedure CLOSE(FILE : in out FILE_TYPE)
    is
    begin
       null;  -- should be defined by implementor
    end CLOSE;

    procedure DELETE(FILE : in out FILE_TYPE) is separate;

    procedure RESET(FILE : in out FILE_TYPE;
               MODE : FILE_MODE) is
    begin
     null; -- should be defined by implementor
    end RESET;

    procedure RESET(FILE : in out FILE_TYPE) is
    begin
     null; -- should be defined by implementor
    end RESET;

    function MODE(FILE : FILE_TYPE) return FILE_MODE is separate;

    function NAME(FILE : FILE_TYPE) return STRING is separate;

    function FORM(FILE : FILE_TYPE) return STRING is separate;

    function IS_OPEN(FILE : FILE_TYPE) return BOOLEAN
    is
       RESULT : BOOLEAN;
    begin
       -- should be defined by implmentor
       return RESULT;
    end IS_OPEN;

    -- Control of default input and output files

    procedure SET_INPUT(FILE : FILE_TYPE) is separate;

    procedure SET_OUTPUT(FILE : FILE_TYPE) is separate;

    procedure SET_ERROR(FILE : FILE_TYPE) is separate;

    function STANDARD_INPUT return FILE_TYPE is separate;

    function STANDARD_OUTPUT return FILE_TYPE is separate;

    function STANDARD_ERROR return FILE_TYPE is separate;
```

```
function CURRENT_INPUT return FILE_TYPE is separate;

function CURRENT_OUTPUT return FILE_TYPE is separate;

function CURRENT_ERROR return FILE_TYPE is separate;




-- Specification of line and page lengths

procedure SET_LINE_LENGTH(FILE : FILE_TYPE;
                          TO   : COUNT) is
begin
 null; -- should be defined by implementor
end SET_LINE_LENGTH;

procedure SET_LINE_LENGTH(TO : COUNT) is
begin
 null; -- should be defined by implementor
end SET_LINE_LENGTH;

procedure SET_PAGE_LENGTH(FILE : FILE_TYPE;
                          TO   : COUNT) is
begin
 null; -- should be defined by implementor
end SET_PAGE_LENGTH;

procedure SET_PAGE_LENGTH(TO : COUNT) is
begin
 null; -- should be defined by implementor
end SET_PAGE_LENGTH;

function LINE_LENGTH (FILE : FILE_TYPE) return COUNT is
   RESULT : COUNT;
begin
   -- should be defined by implementor
   return LINE_LENGTH;
end LINE_LENGTH;

function LINE_LENGTH return COUNT is
   RESULT : COUNT;
begin
   -- should be defined by implementor
   return RESULT;
end LINE_LENGTH;

function PAGE_LENGTH (FILE : FILE_TYPE) return COUNT is
    RESULT : COUNT;
begin
 -- should be defined by implementor
    return RESULT;
end PAGE_LENGTH;

function PAGE_LENGTH return COUNT is
    RESULT : COUNT;
begin
 -- should be defined by implementor
    return RESULT;
end PAGE_LENGTH;


-- Column, Line and Page Control
```

```
procedure NEW_LINE(FILE    : FILE_TYPE;
          SPACING : POSITIVE_COUNT := 1) is
begin
 null; -- should be defined by implementor
end NEW_LINE;

procedure NEW_LINE(SPACING : POSITIVE_COUNT := 1) is
begin
 null; -- should be defined by implementor
end NEW_LINE;

procedure SKIP_LINE(FILE    : FILE_TYPE;
          SPACING : POSITIVE_COUNT := 1) is
begin
 null; -- should be defined by implementor
end SKIP_LINE;

procedure SKIP_LINE(SPACING : POSITIVE_COUNT := 1) is
begin
 null; -- should be defined by implementor
end SKIP_LINE;

function END_OF_LINE (FILE : FILE_TYPE) return BOOLEAN is
   RESULT : BOOLEAN;
begin
 -- should be defined by implementor
    return RESULT;
end END_OF_LINE;

function END_OF_LINE return BOOLEAN is
    RESULT : BOOLEAN;
begin
 -- should be defined by implementor
    return RESULT;
end END_OF_LINE;

procedure NEW_PAGE(FILE : FILE_TYPE) is
begin
 null; -- should be defined by implementor
end NEW_PAGE;

procedure NEW_PAGE is
begin
 null; -- should be defined by implementor
end NEW_PAGE;

procedure SKIP_PAGE(FILE : FILE_TYPE) is
begin
 null; -- should be defined by implementor
end SKIP_PAGE;

procedure SKIP_PAGE is
begin
 null; -- should be defined by implementor
end SKIP_PAGE;

function END_OF_PAGE (FILE : FILE_TYPE) return BOOLEAN is
    RESULT : BOOLEAN;
begin
 -- should be defined by implementor
    return RESULT;
end END_OF_PAGE;

function END_OF_PAGE return BOOLEAN is
```

```
    RESULT : BOOLEAN;
begin
 -- should be defined by implementor
    return RESULT;
end END_OF_PAGE;

function END_OF_FILE (FILE : FILE_TYPE) return BOOLEAN is
    RESULT : BOOLEAN;
begin
 -- should be defined by implementor
    return RESULT;
end END_OF_FILE;

function END_OF_FILE return BOOLEAN is
    RESULT : BOOLEAN;
begin
 -- should be defined by implementor
    return END_OF_FILE;
end END_OF_FILE;


procedure SET_COL(FILE : FILE_TYPE;
              TO   : POSITIVE_COUNT) is
begin
 null; -- should be defined by implementor
end SET_COL;

procedure SET_COL(TO : POSITIVE_COUNT) is
begin
 null; -- should be defined by implementor
end SET_COL;

procedure SET_LINE(FILE : FILE_TYPE;
            TO   : POSITIVE_COUNT) is
begin
 null; -- should be defined by implementor
end SET_LINE;

procedure SET_LINE(TO : POSITIVE_COUNT) is
begin
 null; -- should be defined by implementor
end SET_LINE;


function COL (FILE : FILE_TYPE) return POSITIVE_COUNT is
    RESULT : POSITIVE_COUNT;
begin
 -- should be defined by implementor
    return RESULT;
end COL;

function COL return POSITIVE_COUNT is
    RESULT : POSITIVE_COUNT;
begin
 -- should be defined by implementor
    return RESULT;
end COL;

function LINE (FILE : FILE_TYPE) return POSITIVE_COUNT is
    RESULT : POSITIVE_COUNT;
begin
 -- should be defined by implementor
    return RESULT;
end LINE;
```

```
function LINE return POSITIVE_COUNT is
    RESULT : POSITIVE_COUNT;
begin
 -- should be defined by implementor
    return RESULT;
end LINE;

function PAGE (FILE : FILE_TYPE) return POSITIVE_COUNT is
    RESULT : POSITIVE_COUNT;
begin
 -- should be defined by implementor
    return R' `LT;
end PAGE;

function PAGE return POSITIVE_COUNT is
    RESULT : POSITIVE_COUNT;
begin
    -- should be defined by implementor
    return RESULT;
    PAGE;
end PAGE;



 -- Character Input-Output

procedure GET(FILE : FILE_TYPE; ITEM : out CHARACTER) is
begin
 null; -- should be defined by implementor
end GET;

procedure GET(ITEM : out CHARACTER) is
begin
 null; -- should be defined by implementor
end GET;

procedure PUT(FILE : FILE_TYPE; ITEM : CHARACTER) is
begin
 null; -- should be defined by implementor
end PUT;

procedure PUT(ITEM : CHARACTER) is
begin
 null; -- should be defined by implementor
end PUT;


-- String Input-Output

procedure GET(FILE : FILE_TYPE; ITEM : out STRING) is
begin
 null; -- should be defined by implementor
end GET;

procedure GET(ITEM : out STRING) is
begin
 null; -- should be defined by implementor
end GET;

procedure PUT(FILE : FILE_TYPE; ITEM : STRING) is
begin
 null; -- should be defined by implementor
end PUT;
```

```
    procedure PUT(ITEM : STRING) is
    begin
     null; -- should be defined by implementor
    end PUT;

    procedure GET_LINE(FILE : FILE_TYPE;
              ITEM : out STRING;
              LAST : out NATURAL) is
    begin
     null; -- should be defined by implementor
    end GET_LINE;

    procedure GET_LINE(ITEM : out STRING;
              LAST : out NATURAL) is
    begin
     null; -- should be defined by implementor
    end GET_LINE;

    procedure PUT_LINE(FILE : FILE_TYPE; ITEM : STRING) is
    begin
     null; -- should be defined by implementor
    end PUT_LINE;

    procedure PUT_LINE(ITEM : STRING) is
    begin
     null; -- should be defined by implementor
    end PUT_LINE;

    -- generic package for Input-Output of Integer Types

    package body INTEGER_IO is separate;
    -- generic package for Input-Output of Floating Point Types

    package body FLOAT_IO is separate;

    -- generic package for Input-Output of Fixed Point Types

    package body FIXED_IO is separate;

    -- generic package for Input-Output of Enumeration Types

    package body ENUMERATION_IO is separate;

end TEXT_IO;


separate (CAIS)
package body SCROLL_TERMINAL is
    use NODE_DEFINITIONS;
    use NODE_MANAGEMENT;
    use DEFINITIONS;
    use TEXT_IO;

    procedure SET_POSITION(TERMINAL : FILE_TYPE;
                   POSITION : POSITION_TYPE)
    is
    begin
       null; -- should be defined by implementor
    end SET_POSITION;

    procedure SET_POSITION(POSITION : POSITION_TYPE) is
    begin
     SET_POSITION (CURRENT_OUTPUT, POSITION);
    end SET_POSITION;
```

```
function GET_POSITION (TERMINAL : FILE_TYPE)
              return POSITION_TYPE
is
   RESULT : POSITION_TYPE;
begin
   -- should be defined by implementor
   return RESULT;
end GET_POSITION;

function GET_POSITION return POSITION_TYPE is
begin
 return GET_POSITION (CURRENT_OUTPUT);
end GET_POSITION;


function TERMINAL_SIZE (TERMINAL : FILE_TYPE)
                                     return POSITION_TYPE
is
   RESULT : POSITION_TYPE;
begin
   -- should be defined by implementor
   return RESULT;
end TERMINAL_SIZE;

function TERMINAL_SIZE return POSITION_TYPE is
begin
 return TERMINAL_SIZE (CURRENT_OUTPUT);
end TERMINAL_SIZE;


procedure SET_TAB
       (TERMINAL : FILE_TYPE;
        KIND     : TAB_ENUMERATION := HORIZONTAL)
is
begin
   -- should be defined by implementor
   null;
end SET_TAB;

procedure SET_TAB(KIND : TAB_ENUMERATION := HORIZONTAL) is
begin
 SET_TAB (CURRENT_INPUT, KIND);
end SET_TAB;


procedure CLEAR_TAB
       (TERMINAL : FILE_TYPE;
        KIND     : TAB_ENUMERATION := HORIZONTAL)
is
begin
   -- should be defined by implementor
   null;
end CLEAR_TAB;

procedure CLEAR_TAB(KIND : TAB_ENUMERATION := HORIZONTAL) is
begin
 CLEAR_TAB (CURRENT_OUTPUT, KIND);
end CLEAR_TAB;


procedure TAB(TERMINAL : FILE_TYPE;
         KIND     : TAB_ENUMERATION := HORIZONTAL;
         COUNT    : POSITIVE := 1)
is
```

```
begin
   -- should be defined by implementor
   null;
end TAB;

procedure TAB(KIND  : TAB_ENUMERATION := HORIZONTAL;
        COUNT : POSITIVE := 1) is
begin
 TAB (CURRENT_OUTPUT, KIND, COUNT);
end TAB;


procedure BELL(TERMINAL : FILE_TYPE)
is
begin
   -- should be defined by implementor
   null;
end BELL;

procedure BELL is
begin
 BELL (CURRENT_OUTPUT);
end BELL;

procedure PUT(TERMINAL : FILE_TYPE; ITEM : CHARACTER)
is
begin
   -- should be defined by implementor
   null;
end PUT;

procedure PUT(ITEM : CHARACTER) is
begin
 PUT (CURRENT_OUTPUT, ITEM);
end PUT;


procedure PUT(TERMINAL : FILE_TYPE; ITEM : STRING) is
begin
 for INDEX in ITEM'FIRST .. ITEM'LAST loop
     PUT (TERMINAL, ITEM (INDEX));
 end loop;
end PUT;


procedure PUT(ITEM : STRING) is
begin
 PUT (CURRENT_OUTPUT, ITEM);
end PUT;


procedure SET_ECHO(TERMINAL : FILE_TYPE;
                   TO       : BOOLEAN := TRUE)
is
begin
   -- should be defined by implementor
   null;
end SET_ECHO;

procedure SET_ECHO(TO : BOOLEAN := TRUE) is
begin
 SET_ECHO (CURRENT_INPUT, TO);
end SET_ECHO;
```

```
function ECHO (TERMINAL : FILE_TYPE) return BOOLEAN
                                        is separate;

function ECHO return BOOLEAN is
begin
 return ECHO (CURRENT_INPUT);
end ECHO;


function MAXIMUM_FUNCTION_KEY (TERMINAL : FILE_TYPE)
              return NATURAL
is
   RESULT : NATURAL;
begin
   -- should be defined by implementor
   return RESULT;
end MAXIMUM_FUNCTION_KEY;

function MAXIMUM_FUNCTION_KEY return NATURAL is
begin
 return MAXIMUM_FUNCTION_KEY (CURRENT_INPUT);
end MAXIMUM_FUNCTION_KEY;


procedure GET(TERMINAL : FILE_TYPE;
         ITEM     : out CHARACTER;
         KEYS     : out FUNCTION_KEY_DESCRIPTOR) is
begin
 null; -- should be defined by implementor
end GET;

procedure GET(ITEM : out CHARACTER;
         KEYS : out FUNCTION_KEY_DESCRIPTOR) is
begin
 GET (CURRENT_OUTPUT, ITEM, KEYS);
end GET;


procedure GET(TERMINAL : FILE_TYPE;
         ITEM     : out STRING;
         LAST     : out NATURAL;
         KEYS     : out FUNCTION_KEY_DESCRIPTOR) is
begin
 null; -- should be defined by implementor
end GET;

procedure GET(ITEM : out STRING;
         LAST : out NATURAL;
         KEYS : out FUNCTION_KEY_DESCRIPTOR) is
begin
 GET (CURRENT_INPUT, ITEM, LAST, KEYS);
end GET;


function FUNCTION_KEY_COUNT
         (KEYS : FUNCTION_KEY_DESCRIPTOR)
              return NATURAL
is
   RESULT : NATURAL;
begin
   -- should be defined by implementor
   return RESULT;
end FUNCTION_KEY_COUNT;
```

```
procedure FUNCTION_KEY
        (KEYS           : FUNCTION_KEY_DESCRIPTOR;
         INDEX          : POSITIVE;
         KEY_IDENTIFIER : out POSITIVE;
         POSITION       : out NATURAL)
is
begin
   -- should be defined by implementor
   null;
end FUNCTION_KEY;

procedure FUNCTION_KEY_NAME
        (TERMINAL       : FILE_TYPE;
         KEY_IDENTIFIER : POSITIVE;
         KEY_NAME       : out STRING;
         LAST           : out POSITIVE)
is
begin
   -- should be defined by implementor
   null;
end FUNCTION_KEY_NAME;

procedure FUNCTION_KEY_NAME
        (KEY_IDENTIFIER : POSITIVE;
         KEY_NAME       : out STRING;
         LAST           : out POSITIVE) is
begin
 FUNCTION_KEY_NAME
    (CURRENT_INPUT, KEY_IDENTIFIER, KEY_NAME, LAST);
end FUNCTION_KEY_NAME;


procedure NEW_LINE(TERMINAL : FILE_TYPE;
          COUNT    : POSITIVE := 1) is separate;

procedure NEW_LINE(COUNT : POSITIVE := 1) is
begin
 NEW_LINE (CURRENT_OUTPUT, COUNT);
end NEW_LINE;


procedure NEW_PAGE(TERMINAL : FILE_TYPE) is separate;

procedure NEW_PAGE is
begin
 NEW_PAGE (CURRENT_OUTPUT);
end NEW_PAGE;

end SCROLL_TERMINAL;

separate (CAIS)
package body PAGE_TERMINAL is
    use NODE_DEFINITIONS;
    use NODE_MANAGEMENT;
    use IO_DEFINITIONS;
    use TEXT_IO;

    procedure SET_POSITION(TERMINAL : FILE_TYPE;
                           POSITION : POSITION_TYPE)
    is
    begin
       null; -- should be defined by implementor
    end SET_POSITION;
```

```
procedure SET_POSITION(POSITION : POSITION_TYPE) is
begin
 SET_POSITION (CURRENT_OUTPUT, POSITION);
end SET_POSITION;


function GET_POSITION (TERMINAL : FILE_TYPE)
              return POSITION_TYPE
is
   RESULT : POSITION_TYPE;
begin
   -- should be defined by implementor
   return RESULT;
end GET_POSITION;

function GET_POSITION return POSITION_TYPE is
begin
 return GET_POSITION (CURRENT_OUTPUT);
end GET_POSITION;


function TERMINAL_SIZE (TERMINAL : FILE_TYPE)
                                    return POSITION_TYPE
is
   RESULT : POSITION_TYPE;
begin
   -- should be defined by implementor
   return RESULT;
end TERMINAL_SIZE;

function TERMINAL_SIZE return POSITION_TYPE is
begin
 return TERMINAL_SIZE (CURRENT_OUTPUT);
end TERMINAL_SIZE;


procedure SET_TAB
       (TERMINAL : FILE_TYPE;
        KIND     : TAB_ENUMERATION := HORIZONTAL)
is
begin
   -- should be defined by implementor
   null;
end SET_TAB;

procedure SET_TAB(KIND : TAB_ENUMERATION := HORIZONTAL) is
begin
 SET_TAB (CURRENT_INPUT, KIND);
end SET_TAB;


procedure CLEAR_TAB
       (TERMINAL : FILE_TYPE;
        KIND     : TAB_ENUMERATION := HORIZONTAL)
is
begin
   -- should be defined by implementor
   null;
end CLEAR_TAB;

procedure CLEAR_TAB(KIND : TAB_ENUMERATION := HORIZONTAL) is
begin
 CLEAR_TAB (CURRENT_OUTPUT, KIND);
end CLEAR_TAB;
```

```
procedure TAB(TERMINAL : FILE_TYPE;
        KIND     : TAB_ENUMERATION := HORIZONTAL;
        COUNT    : POSITIVE := 1)
is
begin
   -- should be defined by implementor
   null;
end TAB;

procedure TAB(KIND  : TAB_ENUMERATION := HORIZONTAL;
        COUNT : POSITIVE := 1) is
begin
 TAB (CURRENT_OUTPUT, KIND, COUNT);
end TAB;


procedure BELL(TERMINAL : FILE_TYPE)
is
begin
   -- should be defined by implementor
   null;
end BELL;

procedure BELL is
begin
 BELL (CURRENT_OUTPUT);
end BELL;


procedure PUT(TERMINAL : FILE_TYPE;
        ITEM     : CHARACTER)
is
begin
   -- should be defined by implementor
   null;
end PUT;

procedure PUT(ITEM : CHARACTER) is
begin
 PUT (CURRENT_OUTPUT, ITEM);
end PUT;


procedure PUT(TERMINAL : FILE_TYPE; ITEM : STRING) is
begin
 for INDEX in ITEM'FIRST .. ITEM'LAST loop
     PUT (TERMINAL, ITEM (INDEX));
 end loop;
end PUT;


procedure PUT(ITEM : STRING) is
begin
 PUT (CURRENT_OUTPUT, ITEM);
end PUT;


procedure SET_ECHO(TERMINAL : FILE_TYPE;
                      TO       : BOOLEAN :  TRUE)
is
begin
   -- should be defined by implementor
   null;
end SET_ECHO;
```

```
procedure SET_ECHO(TO : BOOLEAN := TRUE) is
begin
 SET_ECHO (CURRENT_INPUT, TO);
end SET_ECHO;


function ECHO (TERMINAL : FILE_TYPE) return BOOLEAN
                                        is separate;

function ECHO return BOOLEAN is
begin
 return ECHO (CURRENT_INPUT);
end ECHO;


function MAXIMUM_FUNCTION_KEY (TERMINAL : FILE_TYPE)
                return NATURAL
is
   RESULT : NATURAL;
begin
   -- should be defined by implementor
   return RESULT;
end MAXIMUM_FUNCTION_KEY;

function MAXIMUM_FUNCTION_KEY return NATURAL is
begin
 return MAXIMUM_FUNCTION_KEY (CURRENT_INPUT);
end MAXIMUM_FUNCTION_KEY;


procedure GET(TERMINAL : FILE_TYPE;
         ITEM     : out CHARACTER;
         KEYS     : out FUNCTION_KEY_DESCRIPTOR) is
begin
 null; -- should be defined by implementor
end GET;

procedure GET(ITEM : out CHARACTER;
         KEYS : out FUNCTION_KEY_DESCRIPTOR) is
begin
 GET (CURRENT_OUTPUT, ITEM, KEYS);
end GET;


procedure GET(TERMINAL : FILE_TYPE;
         ITEM     : out STRING;
         LAST     : out NATURAL;
         KEYS     : out FUNCTION_KEY_DESCRIPTOR) is
begin
 null; -- should be defined by implementor
end GET;

procedure GET(ITEM : out STRING;
         LAST : out NATURAL;
         KEYS : in out FUNCTION_KEY_DESCRIPTOR) is
begin
 GET (CURRENT_INPUT, ITEM, LAST, KEYS);
end GET;


function FUNCTION_KEY_COUNT
         (KEYS : FUNCTION_KEY_DESCRIPTOR)
                 return NATURAL
is
```

```
begin
   -- should be defined by implementor
   null;
end FUNCTION_KEY_COUNT;

procedure FUNCTION_KEY
       (KEYS           : FUNCTION_KEY_DESCRIPTOR;
        INDEX          : POSITIVE;
        KEY_IDENTIFIER : out POSITIVE;
        POSITION       : out NATURAL)
is
begin
   -- should be defined by implementor
   null;
end FUNCTION_KEY;

procedure FUNCTION_KEY_NAME
       (TERMINAL       : FILE_TYPE;
        KEY_IDENTIFIER : POSITIVE;
        KEY_NAME       : out STRING;
        LAST           : out POSITIVE)
is
begin
   -- should be defined by implementor
   null;
end FUNCTION_KEY_NAME;

procedure FUNCTION_KEY_NAME
       (KEY_IDENTIFIER : POSITIVE;
        KEY_NAME       : out STRING;
        LAST           : out POSITIVE) is
begin
 FUNCTION_KEY_NAME
    (CURRENT_INPUT, KEY_IDENTIFIER, KEY_NAME, LAST);
end FUNCTION_KEY_NAME;


procedure DELETE_CHARACTER(TERMINAL : FILE_TYPE;
                 COUNT    : POSITIVE := 1) is separate;

procedure DELETE_CHARACTER(COUNT : POSITIVE := 1) is
begin
 DELETE_CHARACTER (CURRENT_OUTPUT, COUNT);
end DELETE_CHARACTER;


procedure DELETE_LINE(TERMINAL : FILE_TYPE;
                COUNT    : POSITIVE) is separate;

procedure DELETE_LINE(COUNT : POSITIVE := 1) is
begin
 DELETE_LINE (CURRENT_OUTPUT, COUNT);
end DELETE_LINE;


procedure ERASE_CHARACTER(TERMINAL : FILE_TYPE;
                 COUNT    : POSITIVE := 1) is separate;

procedure ERASE_CHARACTER(COUNT : POSITIVE := 1) is
begin
 ERASE_CHARACTER (CURRENT_OUTPUT, COUNT);
end ERASE_CHARACTER;
```

```
procedure ERASE_IN_DISPLAY
       (TERMINAL   : FILE_TYPE;
        SELECTION : SELECT_ENUMERATION) is separate;

procedure ERASE_IN_DISPLAY
       (SELECTION : SELECT_ENUMERATION) is
begin
 ERASE_IN_DISPLAY (CURRENT_OUTPUT, SELECTION);
end ERASE_IN_DISPLAY;


procedure ERASE_IN_LINE(TERMINAL   : FILE_TYPE;
                SELECTION : SELECT_ENUMERATION) is separate;

procedure ERASE_IN_LINE(SELECTION : SELECT_ENUMERATION) is
begin
 ERASE_IN_LINE (CURRENT_OUTPUT, SELECTION);
end ERASE_IN_LINE;


procedure INSERT_SPACE(TERMINAL : FILE_TYPE;
               COUNT      : POSITIVE := 1) is separate;

procedure INSERT_SPACE(COUNT : POSITIVE := 1) is
begin
 INSERT_SPACE (CURRENT_OUTPUT, COUNT);
end INSERT_SPACE;


procedure INSERT_LINE(TERMINAL : FILE_TYPE;
              COUNT      : POSITIVE := 1) is separate;

procedure INSERT_LINE(COUNT : POSITIVE :=1) is
begin
 INSERT_LINE (CURRENT_OUTPUT, COUNT);
end INSERT_LINE;


function GRAPHIC_RENDITION_SUPPORT
         (TERMINAL   : FILE_TYPE;
       RENDITION : GRAPHIC_RENDITION_ARRAY)
                    return BOOLEAN is separate;

function GRAPHIC_RENDITION_SUPPORT
         (RENDITION : GRAPHIC_RENDITION_ARRAY)
                    return BOOLEAN is
begin
 return GRAPHIC_RENDITION_SUPPORT
        (CURRENT_OUTPUT, RENDITION);
end GRAPHIC_RENDITION_SUPPORT;


procedure SELECT_GRAPHIC_RENDITION
       (TERMINAL   : FILE_TYPE;
        RENDITION : GRAPHIC_RENDITION_ARRAY :=
                 DEFAULT_GRAPHIC_RENDITION) is separate;

procedure SELECT_GRAPHIC_RENDITION
       (RENDITION   GRAPHIC_RENDITION_ARRAY :=
                 DEFAULT_GRAPHIC_RENDITION) is
begin
 SELECT_GRAPHIC_RENDITION (CURRENT_OUTPUT, RENDITION),
end SELECT_GRAPHIC_RENDITION;

end PAGE_TERMINAL;
```

```
separate (CAIS)
package body FORM_TERMINAL is
    use NODE_DEFINITIONS;
    use NODE_MANAGEMENT;
    use IO_DEFINITIONS;
    use TEXT_IO;

    function MAXIMUM_FUNCTION_KEY (TERMINAL : FILE_TYPE)
                return NATURAL is separate;

    function MAXIMUM_FUNCTION_KEY return NATURAL is
    begin
     return MAXIMUM_FUNCTION_KEY (CURRENT_INPUT);
    end MAXIMUM_FUNCTION_KEY;


    procedure DEFINE_QUALIFIED_AREA
           (FORM       : in out FORM_TYPE;
            INTENSITY  : AREA_INTENSITY := NORMAL;
            PROTECTION : AREA_PROTECTION := PROTECTED;
            INPUT      : AREA_INPUT :=
                      GRAPHIC_CHARACTERS;
            VALUE      : AREA_VALUE := NO_FILL) is separate;

    procedure REMOVE_AREA_QUALIFIER(FORM : in out FORM_TYPE) is
 separate;

    procedure SET_POSITION(FORM     : in out FORM_TYPE;
                   POSITION : POSITION_TYPE) is separate;

    procedure NEXT_QUALIFIED_AREA(FORM  : in out FORM_TYPE;
                      COUNT : POSITIVE := 1) is separate;

    procedure PUT(FORM : in out FORM_TYPE;
            ITEM : PRINTABLE_CHARACTER)
    is
    begin
       null; -- should be defined by implementor
    end PUT;

    procedure PUT(FORM : in out FORM_TYPE; ITEM : STRING) is
    begin
     for INDEX in ITEM'FIRST .. ITEM'LAST loop
        PUT (FORM, ITEM (INDEX)); -- Write a single character
     end loop;
    end PUT;


    procedure ERASE_AREA(FORM : in out FORM_TYPE) is separate;

    procedure ERASE_FORM(FORM : in out FORM_TYPE) is separate;

    procedure ACTIVATE(TERMINAL : FILE_TYPE;
              FORM     : in out FORM_TYPE) is separate;

    procedure GET(FORM : in out FORM_TYPE;
            ITEM : out PRINTABLE_CHARACTER)
    is
    begin
       -- should be defined by implementor
       null;
    end GET;
```

```
procedure GET(FORM : in out FORM_TYPE;
        ITEM : out STRING) is
begin
 for INDEX in ITEM'FIRST .. ITEM'LAST loop
    GET (FORM, ITEM (INDEX)); -- Read a single character
 end loop;
end GET;


function IS_FORM_UPDATED (FORM : FORM_TYPE) return BOOLEAN
                                               is separate;

function TERMINATION_KEY (FORM : FORM_TYPE) return NATURAL
                                               is separate;

function FORM_SIZE (FORM : FORM_TYPE) return POSITION_TYPE
                                         is seperate;

function TERMINAL_SIZE (TERMINAL : FILE_TYPE)
                     return POSITION_TYPE is seperate;

function TERMINAL_SIZE return POSITION_TYPE is
begin
 return TERMINAL_SIZE (CURRENT_OUTPUT);
end TERMINAL_SIZE;


function AREA_QUALIFIER_REQUIRES_SPACE (FORM : FORM_TYPE)
                         return BOOLEAN is
   RESULT : BOOLEAN;
begin
   -- should be defined by implementor
   return RESULT;
end AREA_QUALIFIER_REQUIRES_SPACE;

function AREA_QUALIFIER_REQUIRES_SPACE
        (TERMINAL : FILE_TYPE) return BOOLEAN is
   RESULT : BOOLEAN;
begin
   -- should be defined by implementor
   return RESULT;
end AREA_QUALIFIER_REQUIRES_SPACE;

function AREA_QUALIFIER_REQUIRES_SPACE return BOOLEAN is
begin
 return AREA_QUALIFIER_REQUIRES_SPACE (CURRENT_OUTPUT);
end AREA_QUALIFIER_REQUIRES_SPACE;

end FORM_TERMINAL;

separate (CAIS)
package body MAGNETIC_TAPE is
    use NODE_DEFINITIONS;
    use NODE_MANAGEMENT;

        procedure MOUNT(TAPE_DRIVE: in FILE_TYPE;
                        TAPE_NAME: in REEL_NAME;
                        DENSITY: in POSITIVE) is separate;
        procedure LOAD-UNLABELED(TAPE_DRIVE: in FILE_TYPE;
                                 DENSITY:    in POSITIVE;
                                 BLOCK_SIZE: in POSITIVE)
                                            is separate;
        procedure INITIALIZE_UNLABELED(TAPE_DRIVE: in FILE_TYPE)
                                            is separate;
```

```
        procedure LOAD_LABELED(TAPE_DRIVE: in FILE_TYPE;
                               VOLUME_IDENTIFIER: in VOLUME_STRING;
                               DENSITY: in POSITIVE;
                               BLOCK_SIZE: in POSITIVE)
                                                      is separate;
        procedure INITIALIZE_LABELED(TAPE_DRIVE: in FILE_TYPE;
                               VOLUME_IDENTIFIER: in VOLUME_STRING;
                               ACCESSIBILITY: in CHARACTER :=' ')
                                                      is separate;
        procedure UNLOAD(TAPE_DRIVE: in FILE_TYPE)
                                                      is separate;
        procedure DISMOUNT(TAPE_DRIVE: in FILE_TYPE)
                                                      is separate;
        function IS_LOADED(TAPE_DRIVE: in FILE_TYPE)
                   return BOOLEAN is separate;
        function IS_MOUNTED(TAPE_DRIVE: in FILE_TYPE)
                   return BOOLEAN is separate;
        function TAPE_STATUS(TAPE_DRIVE: in FILE_TYPE)
                   return TAPE_POSITION is separate;
        procedure REWIND_TAPE(TAPE_DRIVE: in FILE_TYPE)
                                                      is separate;
        procedure SKIP_TAPE_MARKS(TAPE_DRIVE: in FILE_TYPE;
                                  NUMBER: in INTEGER :=1;
                                  TAPE_STATE:  out TAPE_POSITION)
                                                      is separate;
        procedure WRITE_TAPE_MARK(TAPE_DRIVE: FILE_TYPE;
                                  NUMBER: POSITIVE :=1;
                                  TAPE_STATE: out TAPE_POSITION)
                                                      is separate;
        procedure VOLUME_HEADER(TAPE_DRIVE: FILE_TYPE;
                             VOLUME_IDENTIFIER: VOLUME_STRING;
                             ACCESSIBILITY: CHARACTER :=' ')
                                                      is separate;
        procedure FILE_HEADER(TAPE_DRIVE: FILE_TYPE;
                             FILE_IDENTIFIER: FILE_STRING;
                             EXPIRATION_DATE: STRING :=" 99366";
                             ACCESSIBILITY: CHARACTER :=' ')
                                                      is separate;
        procedure END_FILE_LABEL(TAPE_DRIVE: FILE_TYPE)
                                                      is separate;
        procedure READ_LABEL(TAPE_DRIVE: FILE_TYPE;
                            LABEL: out LABEL_STRING)
                                                      is separate;


    end MAGNETIC_TAPE;

    package FILE_IMPORT_EXPORT is
        use NODE_DEFINITIONS;
        procedure IMPORT (NODE : NODE_TYPE;
                  HOST_FILE_NAME : STRING) is separate;
        procedure IMPORT(NAME: in NAME_STRING;
                  HOST_FILE_NAME: in STRING) is separate;
        procedure EXPORT (NODE : NODE_TYPE;
                  HOST_FILE_NAME : STRING) is separate;
        procedure EXPORT(NAME: in NAME_STRING;
                  HOST_FILE_NAME: in STRING) is separate;

    end FILE_IMPORT_EXPORT;

separate (CAIS)
```

```
package body LIST_UTILITIES is
    use NODE_DEFINITIONS;
    use NODE_MANAGEMENT;
        procedure COPY(TO_LIST: LIST_TYPE;
                       FROM_LIST: LIST_TYPE)
                               is separate;

        function  TO_LIST       (LIST_STRING: STRING)
                                 return LIST_TYPE
                                        is separate;
        function  TO_TEXT       (LIST_ITEM : LIST_TYPE)
                                 return LIST_TEXT
                                        is separate;
        function  IS_EQUAL(LIST1: LIST_TYPE;
                           LIST2: LIST_TYPE)
                  return BOOLEAN is separate;

        function  EXTRACT  (LIST      : LIST_TYPE;
                            POSITION : POSITION_COUNT)
                             return LIST_TYPE
                                    is separate;
        function  EXTRACT  (LIST  : LIST_TYPE;
                            NAMED : NAME_STRING)
                             return LIST_TYPE
                                    is separate;
        function  EXTRACT  (LIST  : LIST_TYPE;
                            NAMED : TOKEN_TYPE)
                             return LIST_TYPE
                                    is separate;
        procedure REPLACE  (LIST      : in out LIST_TYPE;
                            LIST_ITEM : LIST_TYPE;
                            POSITION  : POSITION_COUNT)
                                    is separate;
        procedure REPLACE  (LIST      : in out LIST_TYPE;
                            LIST_ITEM : LIST_TYPE;
                            NAMED     : NAME_STRING)
                                    is separate;
        procedure REPLACE  (LIST      : in out LIST_TYPE;
                            LIST_ITEM : LIST_TYPE;
                            NAMED     : TOKEN_TYPE)
                                    is separate;
        procedure INSERT   (LIST      : in out LIST_TYPE;
                            LIST_ITEM : LIST_TYPE;
                            POSITION  : COUNT)
                                    is separate;
        procedure INSERT   (LIST      : in out LIST_TYPE;
                            LIST_ITEM : LIST_TYPE;
                            NAMED     : NAME_STRING;
                            POSITION  : COUNT)
                                    is separate;
        procedure INSERT   (LIST      : in out LIST_TYPE;
                            LIST_ITEM : LIST_TYPE;
                            NAMED     : TOKEN_TYPE;
                            POSITION  : COUNT)
                                    is separate;
        function  POSITION_BY_VALUE     (LIST  : LIST_TYPE;
                                          VALUE : LIST_TYPE
                                  START_POSITION: POSITION_COUNT
                                   := POSITION_COUNT'FIRST;
                                  END_POSITION: POSITION_COUNT
                                   := POSITION_COUNT'LAST)
                return POSITION_COUNT is separate;
```

```
function  SET_EXTRACT
            (LIST     : LIST_TYPE;
             POSITION : POSITION_COUNT;
             LENGTH   : POSITIVE := POSITIVE'LAST)
                return LIST_TEXT
                          is separate;

procedure SPLICE      (LIST     : in out LIST_TYPE;
                      POSITION : POSITION_COUNT;
                      SUB_LIST : LIST_TEXT)
                          is separate;
procedure SPLICE      (LIST     : in out LIST_TYPE;
                      POSITION : POSITION_COUNT;
                      SUB_LIST : LIST_TYPE)
                          is separate;

procedure DELETE      (LIST     : in out LIST_TYPE;
                      POSITION : POSITION_COUNT)
                          is separate;
procedure DELETE      (LIST  : in out LIST_TYPE;
                      NAMED : NAME_STRING)
                          is separate;
procedure DELETE(LIST: inout LIST_TYPE;
                 NAMED: TOKEN_TYPE)
                          is separate;
function GET_LIST_KIND(LIST: LIST_TYPE)
         return LIST_KIND is separate;

function GET_ITEM_KIND(LIST : LIST_TYPE)
         return LIST_KIND is separate;
function GET_ITEM_KIND(LIST     : LIST_TYPE;
                       POSITION : POSITION_COUNT)
                return ITEM_KIND
                          is separate;
function  GET_ITEM_KIND(LIST  : LIST_TYPE;
                      NAMED : NAME_STRING)
                return ITEM_KIND
                          is separate;
procedure MERGE       (FRONT  : LIST_TYPE;
                      BACK   : LIST_TYPE;
                      RESULT : in out LIST_TYPE)
                          is separate;
function  LENGTH      (LIST : LIST_TYPE) return COUNT
                          is separate;
procedure ITEM_NAME   (LIST       : LIST_TYPE;
                      POSITION   : POSITION_COUNT;
                      NAME       : out TOKEN_TYPE;
                      NAME_RANGE : out POSITIVE)
                          is separate;
function  ITEM_NAME   (LIST     : LIST_TYPE;
                      POSITION : POSITION_COUNT)
                return NAME_STRING
                          is separate;
function POSITION_BY_NAME  (LIST : LIST_TYPE;
                      NAMED      : NAME_STRING)
                return POSITION_COUNT
                          is separate;
function POSITION_BY_NAME  (LIST : LIST_TYPE;
                      NAMED      : TOKEN_TYPE)
                return POSITION_TYPE
                          is separate;

function TEXT_LENGTH       (LIST : LIST_TYPE)
                return NATURAL
```

```
                                        is separate;
function TEXT_LENGTH          (LIST : LIST_TYPE;
                          POSITION   : POSITION_COUNT)
                          return POSITIVE
                                        is separate;
function TEXT_LENGTH          (LIST : LIST_TYPE;
                          NAMED      : NAME_STRING)
                          return POSITIVE
                                        is separate;
function TEXT_LENGTH          (LIST : LIST_TYPE;
                          NAMED      : TOKEN_TYPE)
                          return POSITIVE
                                        is separate;
package IDENTIFIER_ITEM is
    procedure TO_TOKEN(IDENTIFIER: in NAME_STRING;
                           TOKEN:          out TOKEN_TYPE)
                                        is separate;

    function TO_TEXT(LIST_ITEM: in TOKEN_TYPE)
              return NAME_STRING
                                        is separate;

    function IS_EQUAL(TOKEN1: in TOKEN_TYPE;
                          TOKEN2: in TOKEN_TYPE);
              return BOOLEAN is separate;


    procedure EXTRACT(LIST: in LIST_TYPE;
                          POSITION: in POSITION_COUNT;
                          TOKEN:     out TOKEN_TYPE)
                                        is separate;
    procedure EXTRACT(LIST: in LIST_TYPE;
                          NAMED: in NAME_STRING;
                          TOKEN:     out TOKEN_TYPE)
                                        is separate;

    procedure EXTRACT(LIST: in LIST_TYPE;
                          NAMED: in TOKEN_TYPE;
                          TOKEN:     out TOKEN_TYPE)
                                        is separate;

    procedure REPLACE(LIST: in out LIST_TYPE;
                          LIST_ITEM: in TOKEN_TYPE;
                          POSITION: in POSITION_COUNT)
                                        is separate;

    procedure REPLACE(LIST: in out LIST_TYPE;
                          LIST_ITEM: in TOKEN_TYPE;
                          NAMED: in TOKEN_TYPE)
                                        is separate;

    procedure REPLACE(LIST: in out LIST_TYPE;
                          LIST_ITEM: in TOKEN_TYPE;
                          NAMED: in TOKEN_TYPE)
                                        is separate;

    procedure INSERT(LIST: in out LIST_TYPE;
                         LIST_ITEM: in TOKEN_TYPE;
                         POSITION: in COUNT)
                                        is separate;

    procedure INSERT(LIST: in out LIST_TYPE;
                         LIST_ITEM: in TOKEN_TYPE;
```

```
                            NAMED: in NAME_STRING;
                            POSITION: in COUNT)
                                      is separate;

    procedure INSERT(LIST: in out LIST_TYPE;
                     LIST_ITEM: in TOKEN_TYPE;
                     NAMED: in TOKEN_TYPE;
                     POSITION: in COUNT)
                               is separate;

    function POSITION_BY_VALUE(LIST: in LIST_TYPE;
                               VALUE: in TOKEN_TYPE;
                               START_POSITION: in
                                   POSITION_COUNT :=
                                   POSITION_COUNT'FIRST'
                               END_POSITION: in
                                   POSITION_COUNT :=
                                   POSITION_COUNT'LAST)
              return POSITION_COUNT is separate;

end IDENTIFIER_ITEM;

generic
    type NUMBER is range <>;
package INTEGER_ITEM is
    function  EXTRACT  (LIST      : LIST_TYPE;
                        POSITION  : POSITION_COUNT)
                         return NUMBER
                                is separate;
    function  EXTRACT  (LIST   : LIST_TYPE;
                        NAMED  : NAME_STRING)
                         return NUMBER
                                is separate;
    function  FXTRACT  (LIST   : LIST_TYPE;
                        NAMED  : TOKEN_TYPE)
                         return NUMBER
                                is separate;
    procedure REPLACE   (LIST        : in out LIST_TYPE;
                        LIST_ITEM  : NUMBER;
                        POSITION   : POSITION_COUNT)
                                is separate;
    procedure REPLACE   (LIST        : in out LIST_TYPE;
                        LIST_ITEM  : NUMBER;
                        NAMED      : NAME_STRING)
                                is separate;
    procedure REPLACE   (LIST        : in out LIST_TYPE;
                        LIST_ITEM  : NUMBER;
                        NAMED      : TOKEN_TYPE)
                                is separate;
    procedure INSERT    (LIST        : in out LIST_TYPE;
                        LIST_ITEM  : NUMBER;
                        POSITION   : COUNT)
                                is separate;
    procedure INSERT    (LIST        : in out LIST_TYPE;
                        LIST_ITEM  : NUMBER;
                        NAMED      : NAME_STRING;
                        POSITION   : COUNT)
                                is separate;
    procedure INSERT    (LIST        : in out LIST_TYPE;
                        LIST_ITEM  : NUMBER;
                        NAMED      : TOKEN_TYPE;
                        POSITION   : COUNT)
                                is separate;
    function  POSITION_BY_VALUE (LIST   : LIST_TYPE;
```

```
                                        VALUE : NUMBER;
                                        START_POSITION:
                                  POSITION_COUNT:= POSITION_COUNT'FIRST;
                                        END_POSITION: POSITION_COUNT
                                  := POSITION_COUNT'LAST)
                            return POSITION_COUNT is separate;
    end INTEGER_ITEM;
    generic
        type NUMBER is digits <>;
    package FLOAT_ITEM is
        function TO_TEXT(LIST_ITEM: NUMBER)
                            return STRING is separate;

        function  EXTRACT   (LIST      : LIST_TY^E;
                             POSITION : POSITION COUNT)
                              return NUMBER
                                      is separate;
        function  EXTRACT   (LIST  : LIST_TYPE;
                             NAMED : NAME_STRING)
                              return NUMBER
                                      is separate;
        function  EXTRACT   (LIST  : LIST_TYPE;
                             NAMED : TOKEN_TYPE)
                              return NUMBER
                                      is separate;
        procedure REPLACE   (LIST      : in out LIST_TYPE;
                             LIST_ITEM : NUMBER;
                             POSITION  : POSITION_COUNT)
                                      is separate;
        procedure REPLACE   (LIST      : in out LIST_TYPE;
                             LIST_ITEM : NUMBER;
                             NAMED     : NAME_STRING)
                                      is separate;
        procedure REPLACE   (LIST      : in out LIST_TYPE;
                             LIST_ITEM : NUMBER;
                             NAMED     : TOKEN_TYPE)
                                      is separate;
        procedure INSERT    (LIST      : in out LIST_TYPE;
                             LIST_ITEM : NUMBER;
                             POSITION  : COUNT)
                                      is separate;
        procedure INSERT    (LIST      : in out LIST_TYPE;
                             LIST_ITEM : NUMBER;
                             NAMED: NAME_STRING;
                             POSITION  : COUNT)
                                      is separate;
        procedure INSERT    (LIST      : in out LIST_TYPE;
                             LIST_ITEM : NUMBER;
                             NAMED     : NAME_STRING;
                             POSITION  : COUNT)
                                      is separate;
        function  POSITION_BY_VALUE(LIST  : LIST_TYPE;
                                        VALUE : NUMBER;
                                        START_POSITION:
                             POSITION_COUNT:= POSITION_COUNT'FIRST;
                             .          END_POSITION:
                             POSITION_COUNT:= POSITION_COUNT'LAST)
                            return POSITION_COUNT
                                      is separate;
    end FLOAT_ITEM;
    package STRING_ITEM is
        function  EXTRACT   (LIST      : LIST_TYPE;
                             POSITION : POSITION_COUNT)
                              return STRING
```

```
                                is separate;
        function  EXTRACT  (LIST   : LIST_TYPE;
                           NAMED : NAME_STRING)
                            return STRING
                                is separate;
        function  EXTRACT  (LIST   : LIST_TYPE;
                           NAMED : TOKEN_TYPE)
                            return STRING
                                is separate;
        procedure REPLACE   (LIST        : in out LIST_TYPE;
                           LIST_ITEM : STRING;
                           POSITION  : POSITION_COUNT)
                                is separate;
        procedure REPLACE   (LIST        : in out LIST_TYPE;
                           LIST_ITEM : STRING;
                           NAMED     : NAME_STRING)
                                is separate;
        procedure REPLACE   (LIST        : in out LIST_TYPE;
                           LIST_ITEM : STRING;
                           NAMED     : TOKEN_TYPE)
                                is separate;
        procedure INSERT    (LIST        : in out LIST_TYPE;
                           LIST_ITEM : STRING;
                           POSITION  : COUNT)
                                is separate;
        procedure INSERT    (LIST        : in out LIST_TYPE;
                           LIST_ITEM : STRING;
                           NAMED     : NAME_STRING;
                           POSITION  : COUNT)
                                is separate;
        procedure INSERT    (LIST        : in out LIST_TYPE;
                           LIST_ITEM : STRING;
                           NAMED     : TOKEN_TYPE;
                           POSITION  : COUNT)
                                is separate;
        function  POSITION_BY_VALUE    (LIST   : LIST_TYPE;
                           VALUE : STRING
                           START_POSITION: POSITION_COUNT
                                      := POSITION_COUNT'FIRST;
                           END_POSITION: POSITION_COUNT
                                      := POSITION_COUNT'LAST)
                  return POSITION_COUNT
                                is separate;
    end STRING_ITEM;

  private
    type TOKEN_TYPE is (IMPLEMENTATION_DEFINED);
    -- should be defined by implementor
    type LIST_TYPE is (IMPLEMENTATION_DEFINED);
    -- should be defined by implementor

end LIST_UTILITIES;
```

Appendix D. PACKAGE LISTING OF CAIS PROCEDURES AND FUNCTIONS

This appendix lists the CAIS procedures and functions in the context of their associated packages. This appendix is intended to provide a simple reference to the CAIS procedures and functions in package order.

Operation	Description and Interfaces
	Package NODE_MANAGEMENT
Manipulation of node handles	The following interfaces are used for manipulating node handles and determining node handle status and node handle intent. **procedure** OPEN **procedure** CLOSE **procedure** CHANGE_INTENT **function** IS_OPEN **function** INTENT_OF
Querying node kind and name	The following interfaces are used to determine the kind of a node (file, process, or structural) and the primary name of a node. **function** KIND **function** PRIMARY_NAME
Pathname queries	The following interfaces allow queries about pathnames. None of these interfaces perform accesses to nodes; they perform pathname manipulations at the syntactic level only. **function** PRIMARY_NAME **function** PRIMARY_KEY **function** PRIMARY_RELATION **function** PATH_KEY **function** PATH_RELATION **function** BASE_PATH **function** LAST_RELATION **function** LAST_KEY
Node queries	The following interfaces allow queries about nodes. **function** IS_OBTAINABLE **function** IS_SAME **procedure** GET_PARENT
Node duplication interfaces	The following interfaces are used to duplicate single nodes or trees of nodes spanned by primary relationships. **procedure** COPY_NODE **procedure** COPY_TREE

Alteration of relationships	The following interface is used to alter the primary relationship of a node, thereby changing its unique primary name.
	procedure RENAME
Deletion of primary relationships	The following two interfaces allow the deletion of the primary relationship of a single node or of the primary relationships of a node and all the nodes that are contained in the tree spanned by primary relationships emanating from these nodes.
	procedure DELETE_NODE **procedure** DELETE_TREE
Creation and deletion of secondary relationships	The following interfaces allow the creation and deletion of user-defined secondary relationships.
	procedure LINK **procedure** UNLINK
Node iterators	The following interfaces allow the iteration over nodes reachable from a given node via its emanating relationships.
	procedure ITERATE **function** MORE **procedure** GET_NEXT
Manipulation of the CURRENT_NODE relationship	The following interfaces allow changes to the relationship of the predefined relation CURRENT_NODE emanating from the current process node and open a node handle on the node that is the target of such a relatic ship.
	procedure SET_CURRENT_NODE **procedure** GET_CURRENT_NODE

Package ATTRIBUTES

Manipulation of attributes	The following interfaces are used for defining and manipulating the attributes for nodes and relationships.
	procedure CREATE_NODE_ATTRIBUTE **procedure** CREATE_PATH_ATTRIBUTE **procedure** DELETE_NODE_ATTRIBUTE **procedure** DELETE_PATH_ATTRIBUTE **procedure** SET_NODE_ATTRIBUTE **procedure** SET_PATH_ATTRIBUTE

procedure GET_NODE_ATTRIBUTE
procedure GET_PATH_ATTRIBUTE
procedure NODE_ATTRIBUTE_ITERATE
procedure PATH_ATTRIBUTE_ITERATE
function MORE
procedure GET_NEXT

Package ACCESS_CONTROL

Manipulation of access control

The following interfaces are used to manipulate access control information for nodes.

procedure SET_ACCESS_CONTROL
function IS_GRANTED
procedure ADOPT
procedure UNADOPT

Package STRUCTURAL_NODES

Creation of structural node

The following interface is used to create a structural node and to establish the primary relationship to it.

procedure CREATE_NODE

Package PROCESS_CONTROL

Spawning a process

This interface creates a process node, initiates the new process, and returns control to the calling task upon node creation.

procedure SPAWN_PROCESS

Awaiting process termination or abortion

This interface suspends the calling task and waits for the process to terminate or abort.

procedure AWAIT_PROCESS_COMPLETION

Invoking a process

This interface is functionally the same as performing a call to SPAWN_PROCESS followed by a call to AWAIT_PROCESS_COMPLETION.

procedure INVOKE_PROCESS

Creating a new job

This interface creates a new root process node. Control is returned to the calling task after the new job is created.

procedure CREATE_JOB

Examination and modification of results list

These interfaces provide the techniques for a process to examine and modify a results list.

procedure APPEND_RESULTS
procedure WRITE_RESULTS
procedure GET_RESULTS

Determination of state of process and input parameters	These interfaces are used to determine the value of the predefined attributes CURRENT_STATUS and PARAMETERS. **function** STATE_OF_PROCESS **procedure** GET_PARAMETERS
Modification of the status of a process	These interfaces change the process status of a process. **procedure** ABORT_PROCESS **procedure** SUSPEND_PROCESS **procedure** RESUME_PROCESS
Handling I/O and time queries	These interfaces are used to query process nodes to determine the values of the predefined attributes HANDLES_OPEN, IO-UNITS, START_TIME, FINISH_TIME, and MACHINE_TIME. **function** HANDLES_OPEN **function** IO_UNITS **function** START_TIME **function** FINISH_TIME **function** MACHINE_TIME

Packages CAIS.DIRECT_IO, CAIS.SEQUENTIAL_IO, CAIS.TEXT_IO

Creating, opening, and deleting secondary storage file	These interfaces are used to create a file and its file node, to open a handle on a file, and to delete a file. These may be used with direct access, sequential access, and text files. **procedure** CREATE **procedure** OPEN **procedure** DELETE

Package TEXT_IO

Reading and writing characters from/to text file	This procedure is used to read and write characters from/to a text file **procedure** GET **procedure** PUT
Setting predefined relations	These interfaces set the relationships of the predefined relations CURRENT_INPUT, CURRENT_OUTPUT,

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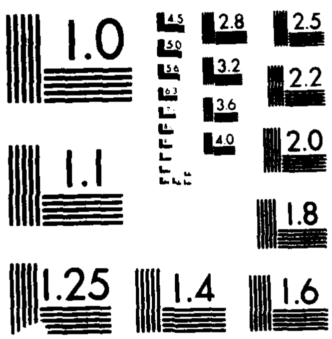
1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

and CURRENT_ERROR.

procedure SET_INPUT
procedure SET_OUTPUT
procedure SET_ERROR

Opening and returning handles on error files

These interfaces are used for returning an open file handle on the error file and for returning an open file handle on the current error output file.

function STANDARD_ERROR
function CURRENT_ERROR

Package IO_CONTROL

Opening a file node

This interface obtains an open node handle from a file handle.

procedure OPEN_FILE_NODE

Transmitting data from internal to external file

This interface is used to transmit data from an internal file to its associated external file.

procedure SYNCHRONIZE

Handling log files, prompts, and function keys

These interfaces are used for performing operations on log files and for handling prompt strings, character arrays, and function keys.

procedure SET_LOG
procedure CLEAR_LOG
function LOGGING
function GET_LOG
function NUMBER_OF_ELEMENTS
procedure SET_PROMPT
function GET_PROMPT
function INTERCEPTED_CHARACTERS
function ENABLED_FUNCTION_KEYS
function FUNCTION_KEYS_ENABLED

Creating coupled queue

This interface creates a queue file and its node. The initial contents of the queue file are the same as those of the file to which it is coupled. The queue file must be of kind MIMIC or COPY.

procedure COUPLE

Package SCROLL_TERMINAL, PAGE_TERMINAL, FORM_TERMINAL

Advancing the

This procedure advances the active position to

active position	the specified position.

procedure SET_POSITION

Package SCROLL_TERMINAL, PAGE_TERMINAL

Querying terminal, controlling tab stop, sounding bell and writing a character	These interfaces are used with scroll and page terminals to determine the active position, determine terminal row and column size, manipulate tab stops, sound the bell, and write a character.

function GET_POSITION
function TERMINAL_SIZE
procedure SET_TAB
procedure CLEAR_TAB
procedure TAB
procedure BELL
procedure PUT

Contolling echo, querying function keys and reading characters function keys	These interfaces are used for echoing characters to associated output devices, determining the maximum allowable function key identification number,reading a character or characters, and determing information about function keys.

procedure SET_ECHO
function ECHO
function MAXIMUM_FUNCTION_KEY
procedure GET
function FUNCTION_KEY_COUNT
procedure FUNCTION_KEY
procedure FUNCTION_KEY_NAME

Package SCROLL_TERMINAL

Line and page advancement	These interfaces are used to control line and page advancement.

procedure NEW_LINE
procedure NEW_PAGE

Package PAGE_TERMINAL

Performing deletions, erasures, and insertions on a page	These interfaces are used for deleting characters characters and lines, for replacing characters entire displays and lines with spaces and for inserting spaces and lines.

procedure DELETE_CHARACTER
procedure DELETE_LINE
procedure ERASE_CHARACTER
procedure ERASE_IN_DISPLAY

procedure ERASE_IN_LINE
procedure INSERT_SPACE
procedure INSERT_LINE

Graphic rendition determination and selection

These interfaces are used for determining if a graphic rendition is supported and for selecting a particular graphic rendition.

function GRAPHIC_RENDITION_SUPPORT
procedure SELECT_GRAPHIC_RENDITION

Package FORM_TERMINAL

Determing maximum value from TERMINATION_KEY

This interface returns the maximum value that may be returned by function TERMINATION_KEY.

function MAXIMUM_FUNCTION_KEY

Opening form and defining qualified area

These interfaces open a form to the specified size, determine if the form is open, define a qualified area, and remove an area qualifier.

procedure DEFINE_QUALIFIED_AREA
procedure REMOVE_AREA_QUALIFIER

Qualified area advancement, writing, and erasing

These interfaces advance the active position to a subsequent qualified area, write to a form, erase a qualified area, and erase the form.

procedure NEXT_QUALIFIED_AREA
procedure PUT
procedure ERASE_AREA
procedure ERASE_FORM

Activating form, reading, and determining information about form

These interfaces activate the form on the terminal, read data from the form, determine if changes have been made to the form, determine the termination key, determine the size of the form and terminal, and determine if the area qualifier requires space.

procedure ACTIVATE
procedure GET
function IS_FORM_UPDATED
function TERMINATION_KEY
function FORM_SIZE
function TERMINAL_SIZE
function AREA_QUALIFIER_REQUIRES_SPACE

Package MAGNETIC_TAPE

Mounting, status checking, and

These are used to load unlabeled and labeled tapes, dismount tapes, determine if a tape is

writing tape marks	loaded or mounted and where it is positioned, skip tape marks, and write a tape mark.

procedure MOUNT
procedure LOAD_UNLABELED
procedure LOAD_LABELED
procedure UNLOAD
procedure DISMOUNT
function IS_LOADED
function IS_MOUNTED
function TAPE_STATUS
procedure REWIND_TAPE
procedure SKIP_TAPE_MARKS
procedure WRITE_TAPE_MARK

Initialize and labeling tapes	These interfaces are used to initialize tapes, to create a volume file header, end of file, read tape label and end of volume label.

procedure INITIALIZE_UNLABELED
procedure INITIALIZE_LABELED
procedure VOLUME_HEADER
procedure FILE_HEADER
procedure END_FILE_LABEL
procedure READ_LABEL
procedure END_OF_VOLUME
procedure RESET

Package FILE_IMPORT_EXPORT

Transferring files between CAIS and host system	These interfaces are used to transfer files between a CAIS implementation and the host file system.

procedure IMPORT
procedure EXPORT

Package LIST_UTILITIES

Creation and conversions of lists	These interfaces are used for converting a list from an external to internal representation.

procedure TO_LIST

Converting identifiers and tokens	These interfaces are used to convert an identifier, which is a list item or name of a list, to a token representation and a token representation to an identifier.

function TO_TOKEN
function IS_EQUAL

function TO_IDENTIFIER

Extracting and inserting subsets of items

These interfaces are used to extract a subset of items from a list and to insert a subset of items into a list.

procedure SPLICE
function SET_EXTRACT

Deleting items from a list and determining list kind

These interfaces are used to delete an item from a list and to determine the kind of list.

procedure DELETE
function GET_LIST_KIND

Determination of kind of list item

This interface is used to determine the kind of list item.

function GET_ITEM_KIND

Merging lists

This interface is used to merge two lists.

procedure MERGE

Querying list characteristics

These interfaces are used to determine the number of items in a list, the name of a list item in a named list and the position of a named item.

function LENGTH
function TEXT_LENGTH
procedure ITEM_NAME
function POSITION_BY_NAME

Package LIST_UTILITIES, INTEGER_ITEM, FLOAT_ITEM, IDENTIFIER_ITEM, STRING_ITEM

Manipulation of items in a list

These interfaces are used to manipulate integer items, floating point items, identifiers represented as tokens lists, and strings that are in a list.

function TO_TEXT
procedure EXTRACT
procedure REPLACE
procedure INSERT
function POSITION_BY_VALUE
procedure TO_TOKEN

Index

Postscript : Submission of Comments

For submission of comments on this proposed MIL-STD-CAIS, we would appreciate them being sent by ARPANET/MILNET to the address

CAIS-COMMENT at ECLB

If you do not have Arpanet access, please send the comments by mail

Patricia Oberndorf
Naval Ocean Systems Center
Code 423
San Diego, CA 92152-5000

For mail comments, it will assist us if you are able to send them on 8-inch single-sided single-density DEC format diskette - but even if you can manage this, please also send us a paper copy, in case of problems with reading the diskette.

All comments are sorted and processed mechanically in order to simplify their analysis and to facilitate giving them proper consideration. To aid this process you are kindly requested to precede each comment with a three line header

!section ...
!version MIL-STD-CAIS
!topic ...
!rationale ...

The section line includes the section number, the paragraph number enclosed in parentheses, your name or affiliation (or both), and the date in ISO standard form (year-month-day). As an example, here is the section line of a comment from a previous version:

!section 03.02.01(12)A. Gargaro 82-04-26

The version line, for comments on the current document, should only contain "MIL-STD-CAIS". Its purpose is to distinguish comments that refer to different versions.

The topic line should contain a one line summary of the comment. This line is essential, and you are kindly asked to avoid topics such as "Typo" or "Editorial comment" which will not convey any information when printed in a table of contents. As an example of an informative topic line, consider:

!topic FILE NODE MANAGEMENT

Note also that nothing prevents the topic line from including all the information of a comment, as in the following topic line:

!topic Insert: "...are {implicitly} defined by a subtype declaration"

As a final example here is a complete comment:

!section 03.02.01(12)A. Gargaro 85-01-15
!version MIL-STD-CAIS
!topic FILE NODE MANAGEMENT
Change "component" to "subcomponent" in the last sentence.

Otherwise the statement is inconsistent with the defined use of subcomponent in 3.3, which says that subcomponents are excluded when the term component is used instead of subcomponent.

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER

2. DOCUMENT TITLE

3a. NAME OF SUBMITTING ORGANIZATION

4. TYPE OF ORGANIZATION (*Mark one*)

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☐ USER

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☐ OTHER (*Specify*): ______

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a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

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DD FORM 1426, [illegible] MAR — PREVIOUS EDITION IS OBSOLETE.

INSTRUCTIONS: In a continuing effort to make our standardization documents better, the DoD provides this form for use in submitting comments and suggestions for improvements. All users of military standardization documents are invited to provide suggestions. This form may be detached, folded along the lines indicated, taped along the loose edge *(DO NOT STAPLE)*, and mailed. In block 5, be as specific as possible about particular problem areas such as wording which required interpretation, was too rigid, restrictive, loose, ambiguous, or was incompatible, and give proposed wording changes which would alleviate the problems. Enter in block 6 any remarks not related to a specific paragraph of the document. If block 7 is filled out, an acknowledgement will be mailed to you within 30 days to let you know that your comments were received and are being considered.

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January 2, 1985

Patricia Oberndorf
Naval Ocean Systems Center
271 Catalina Blvd
San Diego, CA 92152

Dear Tricia:

Enclosed is a copy of the CAIS Standards Coordination Report. I am submitting it for publication in the next KITIA Public Report.

krr

Enclosure

Bernie Abrams

CAIS

STANDARDS COORDINATION REPORT

Bernard Abrams
Software Systems Department
Grumman Aerospace Corp.

Prepared for
Standards Working Group
KITIA
Written: 9 July 1984
Revised: 6 November 1984

INTRODUCTION

This report contains a summary and analysis of standards and specifications that could possibly conflict with CAIS. A list of applicable standards was obtained from various indexes and by asking knowledgeable people. The primary index used was DODISS (Department of Defense index of Standards and Specifications). Both government and industry standards were examined. Standards that were suspected of conflicting or of being redundant with CAIS were read and are reported herein.

DISCUSSION

A summary of the pertinent information on each standard examined is in the body of this report. The summary contains identification of the standard, a short abstract, and a discussion of the connection to CAIS. An index on the next page lists all the standards.

This report would not have been possible without the assistance of the Grumman Aerospace Corp. Engineering Standards Department.

CONCLUSION

Standards that should be examined for possible overlap are:

OSCRL (Operating System Command and Response Language)
DOD STD 1467 Software Support Environment

There are other standards that specify the way a standards document is formatted or the quality control of a program. These must be considered in making CAIS a standard, but have no direct conflict.

INDEX

DETAIL DESCRIPTION

DOCUMENT ID: ANSI/ANS 10.2 1982

TITLE Recommend Programming Practices to Facilitate the Portability of Scientific Computer Programs

DOCUMENT DATE 12 March 1982

AGENCY American Nuclear Society

STATUS Approved

SUMMARY Programming practices are recommended for making application programs portable. The emphasis is on scientific and engineering applications in FORTRAN. Typical recommendations are to avoid extensions to ANSI Fortran.

CONNECTION TO CAIS There is no connection. ANSI 10.2 is concerned with achieving portability by using a common subset of a variety of FORTRAN versions. CAIS achieves portability by standardizing on an operating system interface in an environment where the programming language is standard.

REVIEW DATE 9 July, 1984

....

DOCUMENT ID: ANSI/ANS 10.5 1979

TITLE Guidelines for Considering User Needs in Computer Program Development

DOCUMENT DATE 29 August, 1979

AGENCY American Nuclear Society

STATUS Approved

SUMMARY User concerns are listed including proper application, ease of use, reliability, and time required to obtain results. Design practices to achieve programs that meet the users concerns are modularity, automated adjustment to hardware differences, and minimized input by using default values.

CONNECTION TO CAIS This standard is a good summary of design practices for building user friendly programs, but it is not directly applicable to CAIS because CAIS does not define a human user interface.

REVIEW DATE 9 July, 1984

....

DOCUMENT ID: ANSI X3H1

TITLE OSCRL (Operating System Command & Response Language) Specification 09SD

DOCUMENT DATE 2 February 1984 Revision 20

AGENCY ANSI

STATUS Draft

SUMMARY OSCRL specifies the command language used by a human user to request operating system services. The purpose is to promote portability of people and programs among general purpose computer systems. OSCRL has commands for managing files (COPY, CREATE, DELETE), commands for managing processes (SUBMIT), and a procedural language for controlling commands (IF, LOOP, GO TO, EXIT).

CONNECTION TO CAIS There is a strong connection between CAIS and OSCRL. CAIS specifies the language used by a computer program to call for operating system services. These are the same services that a human user requests with OSCRL. The two languages should be compatible. If both specifications are adopted, then a user will use OSCRL to enter requests which will be translated by a command interpreter to CAIS calls.

There have been discussions of having the user enter commands in Ada. The OSCRL language is not Ada.

There is a definite need to coordinate OSCRL and CAIS since they overlap in many areas. One example is file naming conventions. A detailed comparison of the OSCRL draft with CAIS should be prepared.

REVIEW DATE 9 July, 1984

....

DOCUMENT ID: ANSI/MIL-STD 1815A

TITLE Ada Programming Language

DOCUMENT DATE 22 January 1983

AGENCY Ada Joint Programming Office, DoD

STATUS Approved

SUMMARY Ada Language Reference Manual

CONNECTION TO CAIS In addition to the requirement that CAIS conform to the Ada language, MIL-STD 1815A is a prototype of the format for CAIS. For example the precedent of allowing an exception to the outline of MIL-STD 962 was set by MIL-STD 1815A and followed by CAIS.

REVIEW DATE 9 July, 1984

....

DOCUMENT ID: DoD 4120.3-M

TITLE Defense Standardization and Specification Program, Policies, Procedures and Instructions

DOCUMENT DATE July, 1980

AGENCY DoD

STATUS Mandatory for use by all DoD activities

SUMMARY The organizational procedure for making standards is described. It includes organization and assignments, planning, programming, policies and procedures for standardizing documents.

CONNECTION TO CAIS The procedure for making CAIS a standard is described here.

REVIEW DATE 9 July, 1984

....

DOCUMENT ID: DOD-STD 7935

TITLE Automatic Data System (ADS) Documentation

DOCUMENT DATE 13 September 1977

AGENCY Department of Defense

STATUS Approved

SUMMARY All the documents that must be produced when developing a computer system are describe. Standard outlines are given.

CONNECTION TO CAIS An implementation of CAIS would be an ADS, but CAIS itself is not. It might be considered an FD (Functional Description) which is one of the documents of the development life cycle required by DOD-STD 7935.

REVIEW DATE 9 July, 1984

....

DOCUMENT ID: FIPS PUB 30

TITLE Software Summary for Describing Computer Programs and Automated Data Systems

DOCUMENT DATE 30 June 1974

AGENCY Institute for Computer Science, NBS

STATUS Approved

SUMMARY This publication provides a standard software summary form (SF-185) for describing computer programs and automated data systems for identification, reference, and dissemination purposes.

CONNECTION TO CAIS none

REVIEW DATE 9 July, 1984

....

DOCUMENT ID: FIPS PUB 41

TITLE Computer Security Guidelines for Implementing the Privacy Act of 1974

DOCUMENT DATE 30 May, 1975

AGENCY National Bureau of Standards

STATUS Approved

SUMMARY This is general guidelines for computer security including physical security, entry controls, data encryption, and programming practices.

CONNECTION TO CAIS Nothing in CAIS prevents the implementation of the security provisions of FIPS PUB 41.

REVIEW DATE 9 July, 1984

....

DOCUMENT ID: FIPS PUB 46

TITLE Data Encryption Standard

DOCUMENT DATE 15 January 1977

AGENCY Institute for Computer Science, NBS

STATUS Approved

SUMMARY An algorithm is described for enciphering and deciphering a block of data. The algorithm is applied to data when it leaves a system, and again when it reenters the system. The implementation method is not described. Whether or not the encryption is done in the CPU or in separate modules is not specified.

CONNECTION TO CAIS Encryption translates a given bit pattern into a random pattern. Therefore the transmission system after the point of encryption must pass all bit combinations. Any CAIS feature that prevents the transmission of specific characters could interfere with encryption.

REVIEW DATE 9 July, 1984

....

DOCUMENT ID: IEEE 162-63

TITLE Standard Definition of Terms for Electronic Digital Computers

DOCUMENT DATE Dec 63

AGENCY IEEE

STATUS Approved

SUMMARY This is a hardware oriented glossary.

CONNECTION TO CAIS Possible use in definitions.

REVIEW DATE 9 July, 1984

....

DOCUMENT ID: IEEE STD 730-81

TITLE Standard for Software Quality Assurance Plans

DOCUMENT DATE 1981

AGENCY IEEE

STATUS Approved

SUMMARY This standard describes what a SQAP (Software Quality Assurance Plan) should be. A SQAP applies to a software development project. The activities and documents needed for QA are listed. The minimum activities are SRR (Software Requirements Review), PDR (Preliminary Design Review), CDR (Critical Design Review), SVR (Software Verification Review), Functional Audit, Physical Audit, and In Process Audit. The minimum documents are SRS (Software Requirements Specification), SDD (Software Data Design) SVP (Software Verification Plan) and SVR (Software Verification Report).

CONNECTION TO CAIS The CAIS itself is an interface standard, not executable software, and therefore is not subject to the same QA requirements as a software product. However, CAIS is a product and as such should have some QA plan. A CAIS implementation is software and needs a full QA plan.

REVIEW DATE 9 July, 1984

....

DOCUMENT ID: MIL S 52779A

TITLE Software Quality Assurance Program Requirements

DOCUMENT DATE 1 August, 1979

AGENCY US Army Computer Systems Command

STATUS Approved by Department of Defense

SUMMARY This standard is applicable to computer programs and related data and documentation. A Software Quality Assurance Program is described. Included is the requirement for practices and procedures to assure compliance. In addition the tools, techniques, and methodologies

CONNECTION TO CAIS An implementation of CAIS will require a QA program.

REVIEW DATE 9 July, 1984

....

DOCUMENT ID: MIL-STD 12D

TITLE Abbreviations for Use on Drawings, and in Specifications, Standards, and Technical Drawings.

DOCUMENT DATE 29 May 1981

AGENCY Department of Defense

STATUS Approved

SUMMARY This standard contains a list of approved abbreviations for use in specifications and standards. The list is by the full spelling and is cross referenced by abbreviation. An interesting quote is "when in doubt, spell it out".

CONNECTION TO CAIS Abbreviations in CAIS should not contradict MIL-STD 12D. An abbreviation such as "CAIS" that is too specific to appear in MIL-STD 12D is acceptable.

The approved abbreviation for Identification is IDENT. The use of ID in the CAIS text violates MIL-STD 12D. A non-standard abbreviation may be used in a computer name. Agreement between computer names and MIL-STD 12D is optional. The standard is concerned with abbreviations in text.

REVIEW DATE 9 July, 1984

....

DOCUMENT ID: MIL-STD 483

TITLE Configuration Management Practices For Systems, Equipment, Munitions, And Computer Programs

DOCUMENT DATE 1 June 1971

AGENCY USAF

STATUS Approved

SUMMARY This is one of several standards for configuration management.

CONNECTION TO CAIS This will be important during implementation.

REVIEW DATE 9 July, 1984

....

DOCUMENT ID: MIL STD 961A

TITLE Military Specification, Preparation Of

DOCUMENT DATE 22 September 1981

AGENCY DoD

STATUS Approved

SUMMARY The format of a MIL Specification is described. The use if "will" and "shall", the standard section numbering, style and word usage are specified.

CONNECTION TO CAIS CAIS is a standard, not a specification. A companion document, MIL STD 962 applies to CAIS.

REVIEW DATE 9 July, 1984

....

DOCUMENT ID: MIL STD 962

TITLE Outline of Forms and Instructions for the Preparation of Military Standards

DOCUMENT DATE 22 September, 1975

AGENCY DoD, Defense Electronics Supply Center

STATUS Approved

SUMMARY This standard gives the format of a MIL Standard including word usage, paragraph identification, symbols, format for tables, use of footnotes, and figure sizes. A standardized outline is described.

CONNECTION TO CAIS MIL STD 962 is applicable to CAIS. CAIS does conform in terms of format and style. However CAIS does not follow the standard outline. This exception is necessary because the standard outline does not fit an interface definition like CAIS.

REVIEW DATE 9 July, 1984

....

DOCUMENT ID: MIL-STD 1644

TITLE Trainer System Software Development

DOCUMENT DATE 7 March 1979

AGENCY Naval Trainer Equipment Center

STATUS Approved

SUMMARY This is one of several standards on the procedure for developing software. The others are MIL STD 1679 and MIL STD SDS. The documents required and the procedures to be followed are specified.

CONNECTION TO CAIS None since CAIS is not training equipment

REVIEW DATE 9 July, 1984

....

DOCUMENT ID: MIL-STD 1679

TITLE Weapon System Software Development

DOCUMENT DATE 1 December 1978

AGENCY NAVMAT 09Y

STATUS Approved

SUMMARY This standard controls the way software is developed with emphasis on documents and procedures.

CONNECTION TO CAIS Weapon System software is defined broadly enough to include software development facilities of which CAIS is a part. An implementation of CAIS should follow one of the software development standards.

REVIEW DATE 9 July, 1984

....

DOCUMENT ID: MIL-STD SDS

TITLE Defense System Software Development

DOCUMENT DATE 20 December 1983

AGENCY USAF RADC

STATUS Draft Not Approved

SUMMARY The methods and documents for software development are specified. Structured programming constructs are required. This standard is a replacement for MIL-STD 1679 and MIL-STD 1644.

Important quotes are "the contractor is encouraged to incorporate commercially available software" and "the contractor shall produce code that can be regenerated and maintained using only government-owned or contractually deliverable software."

CONNECTION TO CAIS There is no conflict. This Standard controls the way CAIS is implemented.

REVIEW DATE 9 July, 1984

....

DOCUMENT ID: ANSI X3.102-1983

TITLE Data Communication Systems and Services -User Oriented Performance Parameters

DOCUMENT DATE 22 February, 1983

AGENCY ANSI - Computer and Business Equipment Manufacturers Association

STATUS Approved

SUMMARY The standard defines 21 data communication performance parameters. These parameters quantify the quality of service that a communication system gives a user. A user can be a human operator or an application program.

Some of the parameters defined are access time, incorrect access probability, access denial probability, block transfer time, block error probability, block loss probability, and user information bit transfer rate. No target values are given for any of the parameters.

CONNECTION TO CAIS This specification is important in evaluating a CAIS implementation for performance. Generally performance of an operating system is measured in terms of a vaguely defined parameter like response time. ANSI x3.102 gives rigorously defined performance parameters.

REVIEW DATE 17 September 1984

....

DOCUMENT ID: FIPS PUB 20 (ANSI X10.1-1973)

TITLE Guidelines for Describing Information Interchange Formats

DOCUMENT DATE 1 March 1972

AGENCY National Bureau of Standards Center for Computer Science.

STATUS Approved and adapted by ANSI

SUMMARY Information is collected or interchanged by manual forms, mark sense forms, moveable machine sensible media (cards, tapes, disks), direct on-line entry, or direct online interchange between computers. Usually there are three places where information is described - on an external label, on a machine readable label, and in a document that accompanies the information. This specification is a checklist of the information that goes into the description.

CONNECTION TO CAIS There is no direct connection. This document should be considered in any implementation that has to achieve interoperability of data. Compatible descriptions are needed to transport data.

REVIEW DATE 17 September 1984

....

DOCUMENT ID: DOD-STD 1467

TITLE Software Support Environment

DOCUMENT DATE 1 May, 1984

AGENCY AMCCOM

STATUS Proposed

SUMMARY This standard establishes minimum requirements for the contractor to define a software development support environment to ensure compatibility with a contracting activity's designated life cycle software support environment. It is used with DOD-STD 1679A. The contractor shall ensure and warrant the existence of a capability of the contracting agency to perform software support.

CONNECTION TO CAIS DOD-STD 1467 implies that if the Government uses CAIS for software support, the contractor must warrant that CAIS can be used by the services for maintenance. The contractor need not use CAIS if he can prove that CAIS can support systems developed on the contractors environment.

REVIEW DATE 21 September 1984

....

DOCUMENT ID: FIPS PUB 79 (ANSI X3.27-1078)

TITLE Magnetic Tape Labels and File Structure

DOCUMENT DATE 17 October, 1980

AGENCY National Bureau of Standards

STATUS Approved

SUMMARY FIPS PUB 79 establishes ANSI X3.27-1078 as a federal standard. ANSI X3.27-1978 is referenced and not copied.

CONNECTION TO CAIS See ANSI X3.27-1978

REVIEW DATE 21 September 1984

....

DOCUMENT ID: ANSI X3.27-1978

TITLE Magnetic Tape Labels and File Structures For Information Interchange

DOCUMENT DATE 18 April

AGENCY Institute for Computer Sciences and Technology, American National Standards Institute, Inc.

STATUS Approved

SUMMARY The purpose is to standardize tape label formats so that tapes of different systems can be interchanged. The format of tape labels are defined in detail. Included are volume headers, user volume headers, file labels, and end of file labels. The position and format of each field in a label is defined.

CONNECTION TO CAIS There is no conflict. The exchange of data between systems (interoperability) requires standardization on many levels. CAIS standardizes at an abstract level, the calls from an application program to a system IO package. ANSI X3.27 standardizes at a more physical level, the tape labels. An implementation of CAIS must accept tapes with ANSI X3.27 labels.

REVIEW DATE 24 September 1984

....

DOCUMENT ID: ANSI X3.66-1979

TITLE Advanced Data Communication Control Procedures

DOCUMENT DATE 9 January, 1979

AGENCY ANSI-CBEMA

STATUS submitted for approval

SUMMARY Data communication control procedures define the means for exchanging data between business machines over communication circuits. The advanced data communication control procedures (ADCCP) described are synchronous and bit oriented.

CONNECTION TO CAIS none. Both CAIS and ANSI X3.66 are standards needed to insure interoperability of data, but the two standards address different levels. ANSI X3.66 standardizes the bit stream interchange protocol. CAIS standardizes operating system calls. Standardization at both levels is needed for interoperability.

REVIEW DATE 24 September 1984

....

DOCUMENT ID: IEEE STD 696-1983

TITLE Interface Devices

DOCUMENT DATE 10 July, 1982

AGENCY IEEE

STATUS Approved

SUMMARY The standard applies to interface systems for computer system components interconnected by way of a 100-line parallel backplane commonly known as the S-100 bus. The total transmission path among interconnected devices is less than 25 inches (63.5 cm).

CONNECTION TO CAIS none. Standard 696 controls the hardware interface.

REVIEW DATE 21 September 1984

A Virtual Terminal Specification and Rationale

by

Stewart French
Advanced Computer Systems Laboratory
Texas Instruments, Inc.
Lewisville, Texas 75067

ABSTRACT

The character-imaging computer terminal, consisting of a display device and keyboard, is the most widely used means of communicating with computer systems. Even now, with relatively well developed techniques for device independence, programs tend to be targeted for either specific character-imaging computer terminals or a very small subset of character-imaging computer terminals. A complete intermediate-level virtualization of a character-imaging computer terminal will promote program transportability, high level terminal abstractions, and maximum flexibility for a tool writer. If this intermediate-level virtualization conforms to an existing standard for the device characteristics of the character-imaging computer terminal (ANSI X3 64-1979), there will be many advantageous side-effects. The virtualization will closely match the functional characteristics of the conforming character imaging computer terminals, the virtualization will be more widely accepted, device independence can be promoted, and upward-compatibility of the virtualization will more closely follow the upward-compatibility of the standard.

A Virtual Terminal Specification and Rationale

1 Introduction

This document presents a specification and rationale for an intermediate-level virtualization of character-imaging computer terminals. The information presented covers six areas: an introduction to virtual terminals and device independence; a multi-class and multi-level approach to characterizing existing computer terminals; a four layer approach to terminal virtualization; an introduction to computer terminal standardization efforts; and, conclusions.

A virtual terminal is "a conceptual terminal which is defined as a standard for the purpose of uniform handling of a variety of actual terminals" [DAV79]. There are four goals that should be addressed in specifying a virtual terminal. A virtual terminal should: enhance transportability of programs that perform computer/terminal interaction; provide a common interface for terminals produced by a wide variety of manufacturers; provide the tool developer with an extensive set of interactive terminal control functions; and, provide the virtualization at a level that supports many different models of computer/terminal interaction.

2 An Intermediate Level Virtual Terminal Rationale

The virtual terminal can be defined at many levels. The low level virtual terminal presents the tool writer with a model of the computer terminal that supports direct manipulation of the terminal hardware. An intermediate level virtual terminal presents the tool writer with a model of the computer terminal that closely resembles the functional characteristics of the terminal hardware. The highest level virtual terminal presents the tool writer with a model which hides the functional characteristics of the terminal hardware.

A virtual terminal at the low level provides a tool writer with maximum flexibility. An example of a low level model is the actual device interface presented to the tool writer from a modern operating system. But the tool writer must completely define his own model of the computer terminal with each tool he writes. With many tool writers (alas, even with the same tool writer), many different terminal models at all levels of sophistication could then exist. This would promote confusion. Also, the flexibility gained at this level allows a tool writer to indiscriminantly use facilities of one terminal that may not be available at any other terminal, even with simulation. This promotes undesirable device dependence.

A virtual terminal at a high level imposes a model on the tool writer. An example of a high level model is the concept of equating a physical terminal to a text file and using text file I/O techniques to address and control it. This model tends to hide the functional characteristics of the terminal hardware. It promotes device independence and generally provides a clean interface with the terminal. The disadvantages of this level are twofold. First, the tool writer may wish to define a different model of the computer terminal than the one with which he is presented. He would have to define the new model in terms of the original model that itself does not model the terminal hardware. Even modeling the terminal hardware is awkward. The tool writer must model the terminal hardware in terms of the existing model that hides the hardware. Second, the ability to integrate new terminal hardware into the existing model promises to be very difficult.

An intermediate level virtual terminal that presents the tool writer with a model of a functionally advanced hardware definition of a character-imaging computer terminal permits great flexibility for the tool writer while maintaining a level of abstraction. An example of an intermediate level model is an abstract representation of the functionality found in most advanced computer terminals. Since the virtual terminal models the advanced computer terminal, those functions supported in the

terminal hardware are available to the tool writer directly. Those functions not directly supported in the terminal hardware can be simulated within the virtual terminal. This will be discussed later. The tool writer could then define his own high-level abstract model in terms of this intermediate-level abstract model. Through a proper choice of the intermediate-level interface, the virtual terminal could model most of the terminals on the market today and provide upward-compatibility for new hardware.

3 Device Independence

3.1 Device Independence techniques. Device independence is typically achieved by assuming some standard device and mapping existing devices into the standard. There are essentially three choices for the standard device: the simple device, the complex device, and some device of intermediate complexity.

The simple device is typically the easiest to implement and manipulate. An example of a simple device is a printing terminal. The major problem with the simple approach is that it does not address the advanced features of the computer terminals on the market. A user who purchases a computer terminal with advanced features will reasonably expect to be able to use some of them.

The intermediate complexity device has essentially the same advantages and problems. An example of an intermediate complexity device is a 2-dimensional display device with direct cursor addressibility. It is reasonably easy to implement and manipulate but does not provide the support for the advanced computer terminals on the market. This level would be the most frustrating to work with. A tool writer would begin to get a

flavor of what he wanted to do but may not be able to completely "get at" the features he needs.

The complex device has an interesting set of advantages and disadvantages. An example of a complex device would be an ANSI compatible computer terminal with advanced functions such as graphic rendition (highlighting, blinking, etc), insert line, delete character, etc. The complex device would have a robust set of operations available. A tool writer would be presented with a very complete set of procedures and functions from which to choose to accomplish his goal. He would be able to take advantage of many features available on the most complex computer terminals on the market. The complex device would be the most difficult to implement and manipulate. If a user did not have a computer terminal that supported the operations defined in the complex device, it would be left to the device driver or some simulation level of software to sustain the myth that he did have such a device.

Although the complex device requires some level of simulation to achieve the advanced features on simple terminals, it appears to be the most advantageous approach. Computer terminals are now reaching the market that incorporate many advanced features. The terminal manufacturers are beginning to incorporate the concepts and functionality defined in the ANSI standard X3.64. To conform

to the ANSI standard has very worthwhile effects. It helps formulate the model as a complex device that promotes device independence in character-imaging computer terminals. The conforming computer terminals appear much the same from one manufacturer to another in terms of their operations.

3.2 Device Independence in Existing Applications. Four concepts concerning device independence that are applicable to character-imaging computer terminals are presented in this section. The concept of layered communication is derived from the field of computer networking [DAV79]. The concept of the terminal capabilities database was developed by Bell Labs for the UNIX operating system [UNIX is a registered trademark of Bell Labs] to promote computer terminal device independence [JOY81]. Two concepts are derived from the field of computer graphics: The concept of levels and classes of support [COR79], and the concept of "bundling" attributes [GKS82].

A two level approach to device independence has evolved out of necessity in the field of computer networking. A computer terminal communicates with a local controlling intelligence to perform human/computer interactions. The local intelligence then communicates with the remote host in a standard way to transfer the data the terminal user produced or requested. In this manner, regardless of the actual terminal connected to the local

intelligence, the remote host sees all terminals essentially the same way. It is up to the local intelligence to make use of the features available on the computer terminal. [DAV79]

Bell Labs' UNIX operating system provides the tool writer with a database containing information on many terminals currently on the market. Using the database, a tool can be made device independent to a certain degree. Of course, if a tool writer makes use of a facility of his terminal that is not supported on another terminal, it is up to the tool writer's software to simulate that facility or not proceed with the execution of the program. [JOY81]

The field of computer graphics probably has the most difficult task in trying to achieve device independence. There are many different kinds of graphic devices for both input and output. There are two widely accepted proposed standards for computer graphic devices: the ACM CORE standard [COR79], and the ISO Graphical Kernel System (GKS) [GKS82]. This terminal virtualization does not encompass computer graphics devices; such material is available in the references. The two important derived concepts that are applied to this virtualization are the concept of levels and classes of support from the CORE, and the concept of "bundling" attributes from the GKS.

The GKS standard has defined a method that combines graphic attributes such as color, line width, dashed representation, etc. These attribute combinations are called bundles. For example, a program which draws a line on the display could specify a bundle number of 1. This line drawn on one display device would have a particular representation (such as dotted and red). On another display device the line would perhaps have a different representation (such as solid, thin, and black). Regardless of the eventual representation the same program would execute on either graphics display device. Since the program only specifies the bundle numbers and not the actual representation, it is left to something other than the program to determine the actual representation the user would see at his graphic display device.

The CORE system has a complex set of levels for input, output, and dimension. In order for a given device to provide support for a given set of levels of input, output, and dimension, the device must implement all of the features defined in that combination of levels using any of the following: direct hardware support; hardware simulation support; or software simulation support. It must also implement no features found at higher levels (even if the hardware itself supports it directly).

4 The Virtual Terminal Classes and Levels

To apply the concepts presented above, the terminals are divided into different classes based on their operations and characteristics. A class identifies a set of operations and characteristics that may or may not intersect another classes' set of operations. Each class is subdivided into levels of support. Increasing levels within classes identify additional functionality of the terminals in that class. A level that is said to be above another level within the same class is a superset of the lower level.

The number of classes should be small to incorporate as many different terminals as possible into each class. This increases the amount of simulated functionality for those terminals that do not support every function in its class and increases transportability.

A terminal that appears in a particular class and level must support all of the functionality (and only the functionality) defined in that class.

There are three obvious classifications: the scroll mode terminal, the page mode terminal, and the form mode terminal. These are numbered 0, 1, and 2.

The scroll mode terminal encompasses those terminals that operate like hardcopy terminals. That is, when a carriage return (or any terminator) is typed the terminal scrolls one line upward. The functionality of this terminal class is severely limited and therefore, is the simplest of the terminal classes.

The page mode terminal encompasses those terminals that have a two-dimensional display screen that can be directly addressed and may or may not have any local intelligence (i.e. VT100, Concept-100, Visual-50). This class of terminal encompasses 75 percent of the terminals on the market today.

The form mode terminal encompasses those terminals that have form fill-in capabilities (i.e. IBM 3278). That is, the application program presents the user with a form to fill in on his display screen. The user fills in the form by interacting with the local intelligence and transmits the data to the host through some special keystroke(s) (i.e. ENTER key).

Three levels within each class are defined-- A, B, and C. Level A is composed of those functions within the class that are well

defined and required for a computer terminal to reside in that class. Level B is composed of those functions within the class that are well defined and not required for a computer terminal to reside in that class (advanced functions). Level C is composed of functions that are not well defined and not required for a computer terminal to reside in that class. Level C is meant for special functions that are standardized within a particular installation or organization.

If a computer terminal is in a particular class and level it <u>must</u> support every function defined in that class and level. For those terminals that do not directly support all of the functions defined, there must be some hardware or software simulation of those unsupported functions. If a computer terminal cannot be made to support all of the functions in a class then that terminal cannot be a member of that class and/or level.

5 The Virtual Terminal Layered Structure

Figure 1 presents a four layer approach to the terminal virtualization. The four layers are the user layer, the simulation layer, the translator/driver layer, and the physical terminal.

```
+---------------------------------------------------------------------+
:                                                                     :
:  Procedure/function                                                 :
:    calls                                                            :
:      :        _____                                                 :
:      +---->:       :    User Layer                                  :
:            :       :__                                              :
:            :_______:  :                                             :
:                     __:__                                           :
:                    :       :    Simulation Layer                    :
:                    :       :__                                      :
:                    :_______:  :  generic character codes            :
:                               -                                     :
:                                                                     :
:                               -                                     :
:        Terminal              _:____                                 :
:        Capabilities         :       :    Translator/Driver          :
:        File     -------->   :       :__                             :
:                             :_______:  :  specific character codes  :
:                                      __:__                          :
:                                     :       :    Physical           :
:                                     :       :    Terminal           :
:                                     :_______:                       :
:                                                                     :
+---------------------------------------------------------------------+
```

Figure 1 A Four Layer Approach to Terminal Virtualization

The user layer contains the interface that the tool writer sees. This includes all the functions, procedures, abstract types, and exceptions. At this level of the model the functionality of the complex computer terminal is visible.

The simulation layer supplies the software simulation to create those functions that the physical terminal does not support out of those functions that the physical terminal does support. The simulation layer is written in a high level language (such as ADA or PASCAL) to support changes and additions as required.

The translator/driver layer provides the mapping from device independent generic character codes into device specific character codes. This layer incorporates a variation of the UNIX terminal capabilities database which is used to define the mapping.

The physical terminal layer contains the actual physical terminal. It should be noted that only the translator/driver layer has any knowledge of the exact type of terminal that exists. The simulation layer only knows that specific functions are not available and must be simulated using other generic functions. The user layer only knows that the terminal is of a particular class and level.

The generic character codes that are produced out of the simulation layer conform to ANSI standard X3.64 [ANS79]. As computer terminal manufacturers begin to conform to the standard, the translator/driver and the simulation layer will have less and less to do. And, since the ANSI standard has upward compatibility built into it, the entire four layer approach has the same degree of upward compatibility.

6 Terminal Standardization Efforts

There are two important terminal standardization efforts of interest: the draft standard ISO/DIS 6429.2-1982 [ISO82]; and, the accepted standard ANSI X3.64-1979 [ANS79]. The ISO standard was first proposed as a draft in 1975. It was developed as a synthesis of ANSI X3.64 and ECMA-48 "Additional Controls for Character-Imaging I/O Devices." The ISO standard is a superset of the ANSI standard including additional standardization in the areas of graphic rendition, modes, typographic size selection, and modal interactions. Related standards include [ANS73] [ANS74] [ANS77].

7 ANSI X3.64

It is natural to use the functionality defined in the accepted standard as the complex model of a character-imaging computer terminal. Acceptance is guaranteed by those that accept the standard and wish an intermediate-level virtualization of computer terminals.

ANSI X3.64 "defines a set of encoded control functions to facilitate data interchange with two-dimensional character-imaging input-output devices" [ANS79]. These control functions may be used in either a 7-bit or 8-bit environment following the code structure defined in [ANS74]. The purpose of X3.64 is to provide a set of control functions to accomodate the foreseeable needs in a variety of information interchange applications: interactive terminals of the cathode ray tube type, interactive terminals of the printer type, line printers, microfilm printers, software usage, form filling, composition imaging, word processing, input-output devices with auxiliary devices, and buffered and non-buffered devices. In the creation of a virtual terminal we are interested in only the interactive terminals and form filling terminals. Perhaps this is too limiting, however, it does produce a nice symmetry and limits the scope a great deal. And, since the virtual terminal does conform completely

with the standard, inclusion of other control functions is easily accomplished.

8 The Supported Functions

This section presents the functions that the tool writer can use and that form the intermediate-level computer terminal model. Table 1 presents those operations that are well defined and required for a terminal to be classified a class 0 terminal. Table 2 presents additional operations for class 0 terminals, well defined and not required. Table 3 presents those operations that are well defined and required for a terminal to to be classified a class 1 terminal. This class supports most of the terminals on the market today. Table 4 presents additional operations that are well defined and not required, supporting class 1 terminals. Table 5 presents well defined and required operations for a terminal to be classified a class 2 terminal. The semantics of each of these operations is defined somewhat in the ANSI and ISO standards. It is beyond the scope of this paper to give a complete semantic meaning of each of them

There are no additional operations identified for the class 2 terminal. This will probably change as more data is gathered. Also, note that there are no entries for level c in any class. This is intentional, as this level is reserved for installation extensions.

Certainly other classes are possible, they must simply be identified.

Table 1 Class 0a - Scroll Mode Support

```
+--------------------------------------------------------------+
|                                                              |
|   read_line                                                  |
|   write_line                                                 |
|   update                                                     |
|   open                                                       |
|   close                                                      |
|   set                                                        |
|   reset                                                      |
|     keyboard_action_mode                                     |
|     control_representation_mode                              |
|                                                              |
+--------------------------------------------------------------+
```

Table 2 Class 0b - Additional Functions for Scroll Terminals

```
+--------------------------------------------------------------+
|                                                              |
|   read_character                                             |
|   write_character                                            |
|   select_graphic_rendition                                   |
|   cursor_horizontal_absolute                                 |
|   cursor_horizontal_tab                                      |
|   cursor_tab_control                                         |
|                                                              |
+--------------------------------------------------------------+
```

Table 3 Class 1a - Page Terminal Support

```
+------------------------------------------------------------------------+
|                                                                        |
|  select_graphic_rendition                select_editing_extent         |
|  cursor_horizontal_absolute                edit_in_display             |
|  cursor_next_line                          edit_in_line                |
|  cursor_backward                         passthrough_as_is             |
|  cursor_down                             redraw_display                |
|  cursor_forward                                                        |
|  cursor_position                                                       |
|  cursor_up                                                             |
|  delete_character                                                      |
|  delete_line                                                           |
|  erase_character                                                       |
|  erase_in_display                                                      |
|  erase_in_line                                                         |
|  insert_line                                                           |
|  insert_character                                                      |
|  read_character                                                        |
|  read_line                                                             |
|  read_string                                                           |
|  read_display                                                          |
|  write_character                                                       |
|  write_line                                                            |
|  write_string                                                          |
|  write_display                                                         |
|  update                                                                |
|  open                                                                  |
|  close                                                                 |
|  set                                                                   |
|  reset                                                                 |
|    keyboard_action_mode                                                |
|    control_representation_mode                                         |
|    insertion_replacement_mode                                          |
|    status_reporting_transfer_mode                                      |
|    erasure_mode                                                        |
|    vertical_editing_mode                                               |
|    horizontal_editing_mode                                             |
|    editing_boundary_mode                                               |
|    send_receive_mode                                                   |
|    dynamic_update_mode                                                 |
|    line_feed_new_line_mode                                             |
|  reset_to_initial_state                                                |
|  get_device_characteristics                                            |
|  please_report_status                                                  |
|  please_report_current_position                                        |
|                                                                        |
+------------------------------------------------------------------------+
```

Table 4 Class 1b - Additional Functions for Page Terminal Support

```
cursor_backtab
cursor_horizontal_tab
cursor_tab_control
erase_in_area
define_qualified_area
  accept_all_input
  accept_no_input_and_do_not_transmit
  accept_graphics
  accept_numerics
  accept_alphabetics
  right_justify_in_area
  zero_fill_in_area
  horizontal_tab_stop_at_start_of_area
  accept_no_input_but_select_for_transmission
  space_fill_in_area
read_area
write_area
set
reset
  guarded_area_transfer_mode
  multiple_area_transfer_mode
  transfer_termination_mode
  selected_area_transfer_mode
  editing_boundary_mode
select_editing_extent
  edit_in_qualified_area
```

Table 5 Class 2a - Form Terminal Support

```
erase_in_display
erase_in_area
define_qualified_area
  accept_all_input
  accept_no_input_and_do_not_transmit
  accept_graphics
  accept_numerics
  accept_alphabetics
  right_justify_in_area
  zero_fill_in_area
  horizontal_tab_stop_at_start_of_area
  accept_no_input_but_select_for_transmission
  space_fill_in_area
read_area
write_area
redraw_display
update
open
close
set
reset
  guarded_area_transfer_mode
  keyboard_action_mode
  status_reporting_transfer_mode
  erasure_mode
  multiple_area_transfer_mode
  transfer_termination_mode
  selected_area_transfer_mode
  dynamic_update_mode
reset_to_initial_state
get_device_characteristics
please_report_status
please_report_current_position
passthrough_as_is
```

9 Future Directions

Testing out the model presented with real application programmers and tool writers is the direction in which this model will proceed. This will hopefully answer the questions concerning the model: Is it complete enough? Is it too robust? Where are the deficiencies? It will then be necessary to adjust the operations within the classes to more accurately reflect terminals capabilities.

In the long term, attempts will be made to define new classes to cover terminals that are just beginning to emerge on the market. These terminals begin to approach the functionality of displays found on such workstations as the Apple LISA, Xerox Star, and Smalltalk. Also, support will probably need to be provided for the most simple terminal-like device. An example is an applications in which a device that is not a computer terminal is connected into the physical terminal layer. This could be a hardware debug device or a networking device that needs a completely different model than that presented here. There will be a need to incorporate more operations defined in the ANSI standard as the terminal manufacturers begin incorporating them into their terminals. Along the same lines, consideration should be given to incorporating some of the ISO standard into the

model. Consideration should also be given to the new proposed teletext and videotex standards.

10 Conclusions

Character-imaging computer terminals are complex devices that need to treated as such. This paper presents a virtualization of these types of devices to enhance transportability of programs that perform computer/terminal interaction, to provide a common interface for terminals produced by a wide variety of manufacturers, to provide the tool developer with an extensive set of interactive terminal control functions, and to provide the virtualization at a level that supports many different models of computer/terminal interaction.

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PROTOTYPING THE COMMON APSE INTERFACE SET (CAIS)

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PURPOSE OF PROTOTYPING:

The general purpose of any prototyping activity is to experiment with new ideas. It is a means of assisting a group in learning what the potential problems associated with various solutions would/could possibly be. An apparent problem could have several potential solutions. Prototyping allows us to pursue those potential solutions and also to further define what the original problem is in reality. The purpose of CAIS prototyping activities will be to judge several features of the interface set and to gather feedback which can be used to improve the CAIS.

Prototyping as discussed above actually has three parts. One is the development of the actual prototype itself. The second one is the definition of an experiment which will be designed to determine the answers to some carefully articulated questions regarding the CAIS. The third is the recording of the results of the experiment in such a fashion as to be useful to the technical community (in this case, particularly to the CAIS designers). These three together - implementing a prototype, conducting a planned experiment(s) using it, and then reporting the results in a useful form - are what is meant in the remainder of this paper when the word *"prototyping"* is used.

SUGGESTED EXPERIMENTS:

Many different kinds of experiments should be planned and executed. Each should be carefully designed and planned to determine various aspects of how the CAIS functions in real use. Criteria which will be used to evaluate the CAIS, the prototype implementation and the experiments conducted using it should be established before implementation work begins. Several areas of experimentation are suggested below:

1. CAN THE CAIS BE IMPLEMENTED?

This is the first question which must be answered. In order to determine an answer, many prototypes on many different machines/OSs must be attempted and their results published. It should be made clear that it is not a particularly useful result of such an implementation experiment to simply conclude "we did (did not) succeed in implementing the CAIS." The result of an attempt to provide a prototype implementation will probably not be so black and white. The result should be not only the operational prototype, but a report which explicitly evaluates the CAIS and the prototype implementation with respect to the ease/difficulty encountered, etc., according to the evaluation criteria established before implementation work began.

How many is "many"? Some people have called for at least 2 "major" implementations. This undoubtedly means at least two implementations of the complete interface set on major machine/OS combinations which are in heavy use in the probable CAIS user community and which differ significantly (UNIX[1] on IBM and UNIX on DEC would probably not qualify because the OSs would not be sufficiently different to really prove the general implementability of the CAIS). In some sense, the implementability question is really "Can the CAIS be implemented on a given OS/machine combination?". Once this question has been answered positively "enough" times, the answer to the overall question can be "yes".

More than one group should attempt implementations on the same OS, particularly if it is an especially popular one. This is already happening with the CAIS, as several independent groups are investigating CAIS prototypes based on UNIX. The value of this is the insight gained into the variety of ways in which CAIS features can be approached for implementation and the affects which these choices have on how various features interact with one another in general and on the success of the implementation effort as a whole.

Since many experiments can and will be conducted using only a partial implementation of the CAIS, one preliminary question will have to be answered: is the CAIS amenable to incremental, tailored implementation?

2. CAN THE CAIS BE IMPLEMENTED EFFICIENTLY?

This is the second major question to be answered. This calls for prototypes of a slightly different nature than the first question does. These prototypes will emphasize speed of execution, not speed of implementation. They might well be done independently of any prototype answering question 1, or they might be based on such a prototype, focusing on the design choices which were made for quickness of implementation instead of execution efficiency.

Another aspect of "efficiency" is how much effort is required to produce a reasonable CAIS implementation. Estimates so far range from $500K to $6M and from 6 months calendar time to 10 years. One proposed criterion for "ease of implementation" is that it would take less than 5 manyears over a period of one calendar year. Of course, such figures will vary with the purpose and other parameters of the prototype implementation experiment, but it is another aspect on which we need to gather information. Carefully kept records regarding budgets, calendar time, personnel and machine resources required to implement a given prototype should be a part of any prototype report.

In this case, too, many prototypes are needed. Also, as above, there is value both in a wide variety of such prototypes and in several of them implemented by independent groups on the same machine/OS.

3. CAN USEFUL TOOLS BE IMPLEMENTED USING THE CAIS?

Many different kinds of experiments are needed in this area. One aspect is the ability of the CAIS to support the sorts of

1 ® UNIX ix a registered trademark of AT&T, Bell Laboratories.

tools which are in common use today; the corollary to this experiment would determine which interfaces common tools require which the CAIS does not currently provide. A second aspect is the ability of the CAIS to support the sorts of tools which can be anticipated in the future; an analogous corollary would determine the requirements which more forward-looking tools may place on the interfaces. Another aspect is the ability of the CAIS to capture existing tools; i.e., what are the difficulties encountered in rehosting existing tools on the CAIS. Experiments dealing with such difficulties should consider not only existing tools written in Ada[2], but also the problems which are presented by tools written in other languages and by tool sets. A fourth aspect of tool implementability is what affect the CAIS features have on the design of tools. One useful experiment in this regard might be to take an existing set of tools already rehosted to the CAIS and redesign it to take the best advantage of the CAIS interfaces and implementation.

4. DOES THE CAIS ACHIEVE ITS TRANSPORTABILITY OBJECTIVE?

This is ultimately the experiment that is of interest in demonstrating the original design goal of the CAIS. Such an experiment would be conducted by attempting to move a tool or toolset which has been successfully hosted on one CAIS implementation to another (different) CAIS implementation. Since transportability is not an all or nothing proposition, careful records should be kept regarding the difficulties encountered, the interface changes required, the effort required, etc.; this information would form the basis for estimating how much of the code was transported and how much had to be redone in order for the tool or toolset to execute properly on the new CAIS host. These experiments should be conducted both with tools/toolsets which have been designed to be portable and with those that have not.

In this case as with the others, the more such experiments that are conducted, the more information about the appropriateness and viability of the CAIS can be gathered.

5. CAN THE CAIS BE EXTENDED?

At least three very important future aspects of the CAIS are not yet clearly understood. These and others should be the object of further CAIS prototype experiments. The emphasis in such experiments would shift from proving the utility of what is already in the CAIS to identifying aspects of the CAIS which will either hinder or enable future extensions.

The first identified set of extension experiments should deal with the distributivity of the CAIS. It is recognized by the community as a whole that the direction of implementation of software development and maintenance environments is towards use of multiple computers, possibly including personal workstations, linked together to provide the complete set of capabilities which are available to a user. The CAIS may be called upon to be distributed in either of two modes: either as several independent CAIS implementations capable of communicating and cooperating with one another or as one complete CAIS implementation which spans two or more independent processors. Ex-

2 ® Ada is a registered trademark of the U.S. Government (Ada Joint Program Office).

periments regarding distributivity would have at least two aspects: is the CAIS distributable in either mode (in a transparent sense) as it is now and can explicit interfaces dealing with aspects of distribution in either mode be smoothly integrated with the existing CAIS interfaces.

The second set of extension experiments should deal with the database aspects of the CAIS. These experiments might investigate a number of aspects, such as:

- what sorts of database applications are well supported by the current CAIS?
- what level of database operation should be directly provided by the CAIS?
- what kinds of database-related interfaces are required to be incorporated into the CAIS?
- what sort of database model will best support the widest range of tool requirements?

The database portion of the STONEMAN[3] approach tu an environment is the least understood, least proven and potentially most important part of the new approach to environments. It is a key issue for future versions of the CAIS, so whatever information can be derived from prototypes should be gathered and provided to the CAIS designers.

The third set of extension experiments should deal with the ability of the CAIS to support adequately the sophisticated user interfaces required by such devices as bit-mapped and graphics terminals. It is acknowledged in the initial version of the CAIS that such interfaces are of future interest. Prototypes which help to investigate this aspect of extension are also needed.

6. IS THE SAME CAIS APPROPRIATE FOR BOTH OS AND BARE MACHINE IMPLEMENTATIONS?

This issue has been brought up recently in the KIT/KITIA, but there has not been enough information so far to adequately deal with it. To some extent, the prototypes which will result from questions 1-5 above could provide insight into this issue, but some experiments must be designed explicitly to obtain information in this regard.

FEATURES OF THE CAIS:

Any experiment might be designed to investigate a number of CAIS features. These features include:

- the level of the interfaces (too high, too low, just right)
- the size of the interface set (too large, too small, minimal)
- the determination of interfaces which are least important
- the appropriateness of the underlying node model to the support of

3 Requirements for Ada Programming Support Environments, STONEMAN, Deaprtment of Defense, February 1980.

the requirements of software development and maintenance

- the implementability of the CAIS on a wide range of machine/OS combinations (including bare machines)

- the ease (or difficulty) of implementation

- the compatibility of the CAIS with various security models

- the ability of the CAIS to capture (i.e., be the target of a reasonably straightforward rehosting of) existing tools

- the usability (i.e., by tools and toolwriters) of the interfaces

- the performance/efficiency achievable

- the portability of CAIS implementa tions

- the determination of missing and/or extraneous interfaces

- the applicability of the interfaces

- the distributivity of the CAIS.

Which features are to be investigated by the prototyping activities and how the results will be measured (i.e., what criteria will be used and how the evaluation of the prototype with respect to those criteria will be conducted) should be a part of any experiment design.

ASPECTS REVEALED BY THE EXPERIMENTS:

As experiments addressing the various features and issues are conducted, results will be obtained which can be conveyed to the CAIS designers and to other CAIS users. However, it will be important to distinguish between several aspects of the experiments and/or the implementation which might be revealed by a result of the work. Any given result could be a comment on:

- the interface set

- the underlying CAIS model

- the underlying machine or operating system

- the design or implementation choices made in building the prototype

- the design of the experiment itself

- the team conducting the implementation and experiment.

Other factors might also be involved. It will be very important that the final analyses take into account that any or all of these might have contributed to any given result. For example, it would not be helpful to conclude that some outcome indicated an interface deficiency when the real problem might lie with some feature of the node model or some particular design choice that was made. All final analyses should attempt to determine exactly why an interface was found to be deficient.

KINDS OF PROTOTYPES:

Several different prototype approaches might be used in the experiments which are designed to answer questions about features of the CAIS:

1. Full or partial implementations of the CAIS which are brought up as quickly as possible in order to prove implementability, to provide a base for tool implementation experiments, etc. Such prototypes would not emphasize efficiency of implementation or speed of execution; the primary emphasis would be on functionality.

2. Full or partial implementations of the CAIS which are designed to be as efficient as possible and to execute as quickly as they can on that machine/OS combination. Such prototypes would provide insight into the parameters of CAIS efficiency, implementability for efficiency, implementation tailorability, etc.

3. Full or partial implementations of tools which are designed or converted to execute using the CAIS interfaces. The purpose of such prototypes would be not only to prove the usability of the interfaces for tool implementation but also to provide feedback on additional interfaces which might be usefully added to the CAIS. (Note that this requires 1 or 2 above.)

4. Full implementations of tools or toolsets which are designed to simulate a full APSE and therefore to provide insight into the functioning of the CAIS as the basis for a full APSE.

From the above, it is clear that there are several variables which might be traded off in order to provide a prototype implementation which was best suited to the planned experiments:

- efficiency of implementation
- speed of execution
- completeness of interface set used
- number of tools implemented on top of the CAIS implementation
- type of tool(s) implemented on top of it
- ease of implementation
- evolvability to a viable end-product.

Each prototype will be based on a unique set of design choices which are determined by the objectives of the prototype, the experiments which have been designed for the prototype and the machine/OS combination on which the prototype will be hosted.

CURRENTLY IDENTIFIED EXPERIMENTS:

The following groups are currently planning experiments with CAIS prototype implementations. Some of the prototype implementations are underway.

CAIS PROTOTYPES

Group	Objective	Host	Status
TRW Redondo Beach, CA	Initially a partial implementation for interface feasibility purposes; includes plans to rehost a few existing tools.	UNIX with ARCTURUS on a VAX.	In Implementation
VPI Blacksburg, VA	A semantic definition of the CAIS using Ada.	?	In process .
MITRE Washington, D.C.	A full implementation for interface feasibility purposes.	UNIX on a VAX.	In design.
LOS ALAMOS LAB New Mexico	?	UNIX on ?	In planning.
Gould Florida	?	SEL?	In design.
Intermetrics Cambridge, MA	A partial implementation for support of the AIE compiler.	UTS on IBM ?	In implementation .
VHDL program Washington, D.C.	A partial implementation for support of the VHDL tool set.	?	In implementation .

AdaPAKSS Project

CAIS Prototype Task

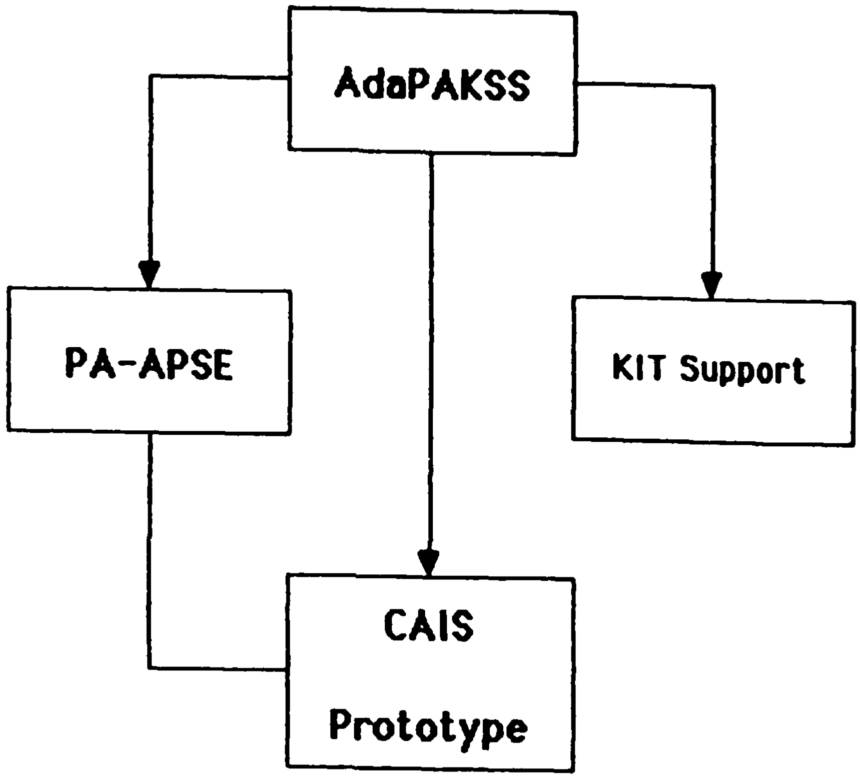
A Report

to

KIT / KITIA

TRW

16 January 1985


AdaPAKSS
PA-APSE
KIT Support
CAIS
Prototype

CAIS Prototype Task Team

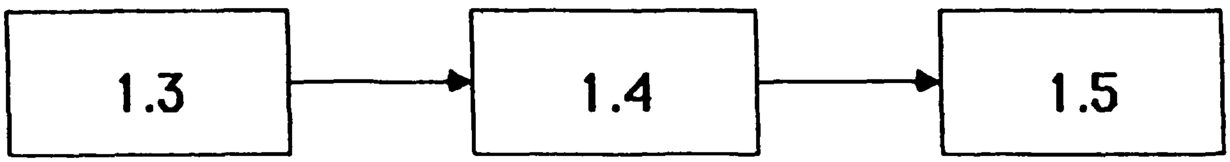
(Hal Hart)

Frank Belz

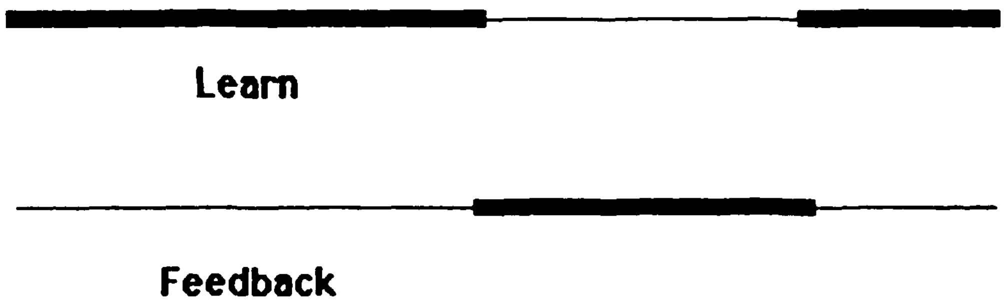
Frank Tadman (UCI / TRW)

Tony Alden

Prototyping a Moving Target



TRW Effort



Establish/Refine Evaluation Criteria

Evaluate The CAIS Itself

Evaluate CAIS Implementations

Evaluating The CAIS Itself

Consistency

Completeness

CAIS Implementability

APSE Implementability

Performance Restrictions

Portability Support

Appropriateness

- Interface Level
- Size of Interface Set
- Relative Importance of Interfaces
- Node Model

Distributivity

Evaluating CAIS Implementations

- Performance
    - Overhead
    - Response
- Size Limitations
- Host System Visibility
    - Tool Capture
    - Data Base Capture
    - Error Recovery
    - Error Reporting

Evaluating CAIS Implementations

(cont.)

Portability

Uniformity & Host Services

Concurrency

Security

- Compatibility with various models
- Encapsulation (Internal vs. External Access Control)

Integrity

Host Invasiveness

Implementation Dependencies

Adaptability

Storage Modeling Approaches

Use

- Main Memory
- Disk Partition
- Disk Segmentation
- Flat Filespace
- Hierarchical (UNIX) File System
- Back End DB Machine

Main Memory

Quick to Implement

Fast (with adequate working set)

Capacity Limitations are Severe

(unless single-level a la Multics)

Check Point/Restore required

Concurrent Users Very Difficult

Disk Partition

Potentially most efficient

Potentially maximal capacity

Potentially portable

Costly to implement

Rebuild much O.S. Software

- Free storage management
- Cylinder optimizations, etc.

Unix kernel invasive

- CAOS acceptable, PAIS unacceptable

Disk Segmentation

Like disk partition, except

- Less costly to implement
- Possibly less Unix-kernel invasive

Hierarchical Filesystem

Potentially high capacity

Not kernel invasive

Not portable

Performance poor

External security weak

- Encapsalation impossible
- Integrity vulnerable

Non-uniform correspondence

Cost risk high

Flat Filespace

Potentially high capacity

Low cost implementation

Abstractly similar to disk segmentation

- adaptable

Not kernel-invasive

Portable

Performance poor

External Security weak

- Encapsulation impossible
- Integrity vulnerable

Back End Database

Capacity: maximal .. supermaximal

Performance: very poor .. supermaximal

Probably very high external security

OS Independent

Back End Database Dependent

- portable wrt. OS, not DB

Implementation cost uncertain

- high variance

Pick a Design Approach

"Cached Segmentation"

Segmentation

- Common Abstraction of
  Disk Segmentation and
  Flat Filespace
- Implementation as Flat
  Filespace

Cached

- Open nodes, relationships
  and attributes cached in
  main memory
- Extension of file buffering

CAIS/OS Process Structure

How to use UNIX processes to achieve:

- CAIS Data Store Access capabilities
- CAIS Access Control
- Concurrency Control

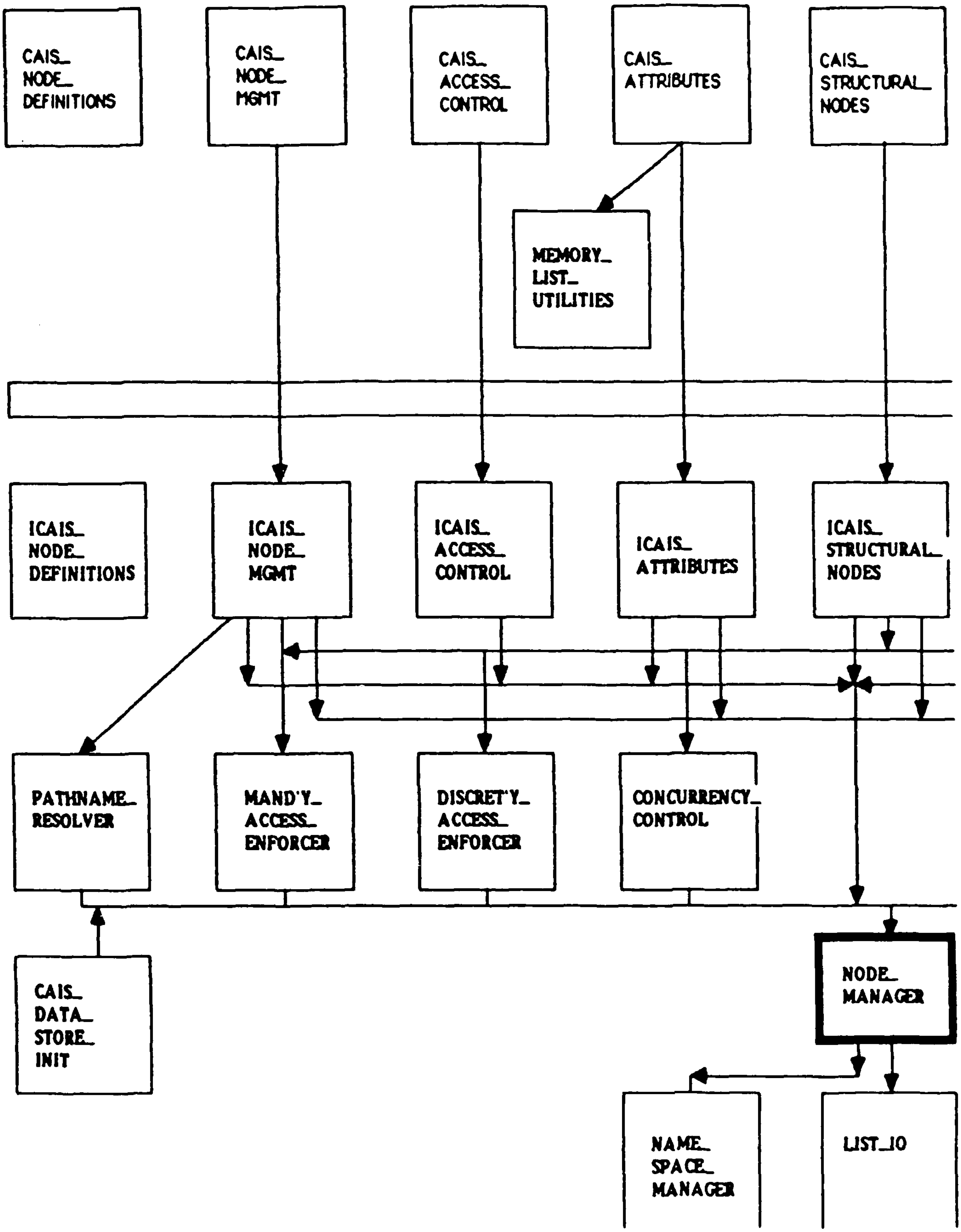
  (serialization of access to data)
- Integrity assurance
- CAIS processes

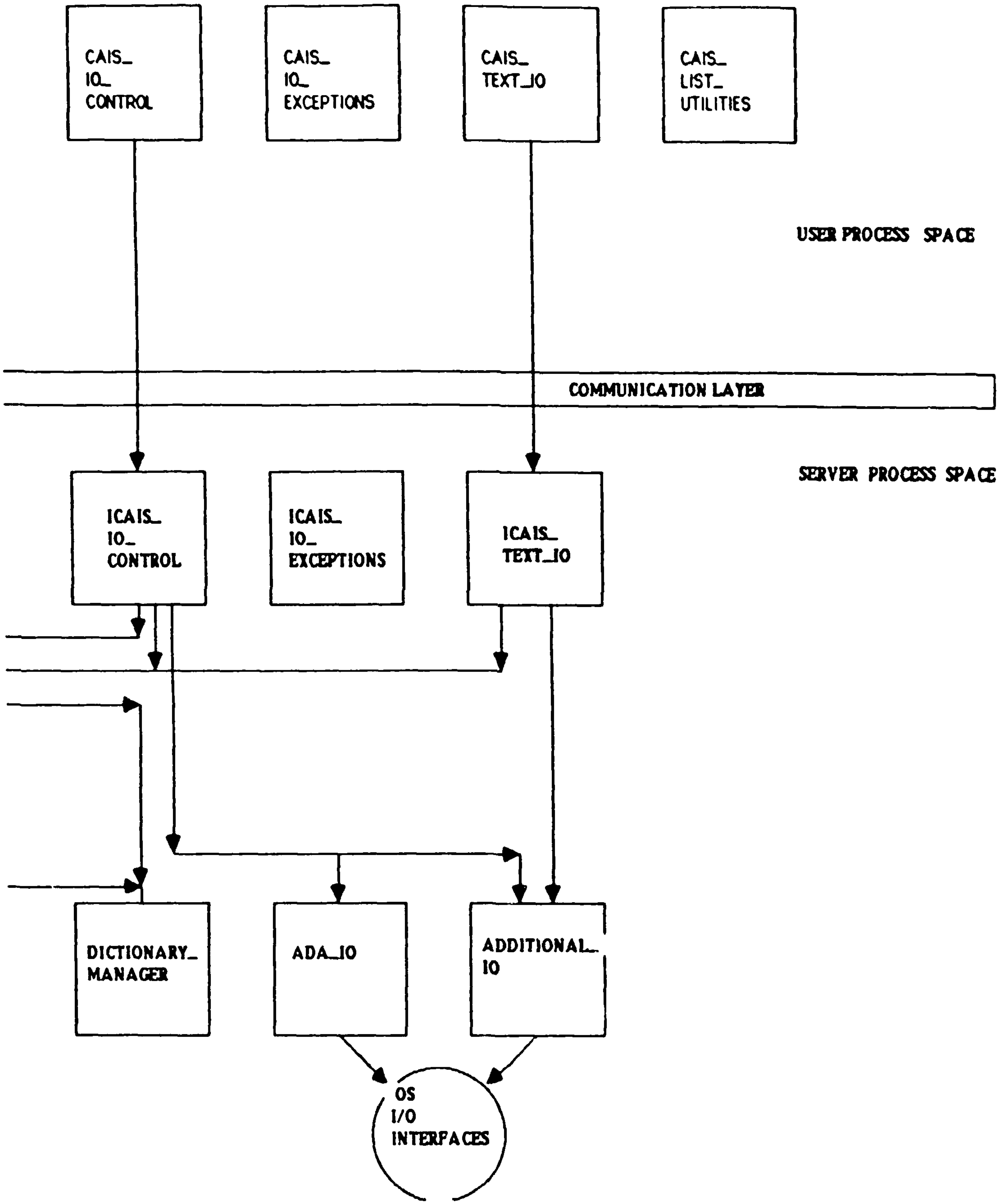
Process Design Options

Data Store Access capabilities

can be placed in:

- **Application UNIX processes**
- **"Companion" UNIX processes**
- **Single Server UNIX process**
- **Within the UNIX kernel**


CAIS_ NODE_ DEFINITIONS
CAIS_ NODE_ MGMT
CAIS_ ACCESS_ CONTROL
CAIS_ ATTRIBUTES
CAIS_ STRUCTURAL_ NODES
MEMORY_ LIST_ UTILITIES
ICAIS_ NODE_ DEFINITIONS
ICAIS_ NODE_ MGMT
ICAIS_ ACCESS_ CONTROL
ICAIS_ ATTRIBUTES
ICAIS_ STRUCTURAL_ NODES
PATHNAME_ RESOLVER
MAND'Y_ ACCESS_ ENFORCER
DISCRET'Y_ ACCESS_ ENFORCER
CONCURRENCY_ CONTROL
CAIS_ DATA_ STORE_ INIT
NODE_ MANAGER
NAME_ SPACE_ MANAGER
LIST_IO



CAIS_ IO_ CONTROL
CAIS_ IO_ EXCEPTIONS
CAIS_ TEXT_IO
CAIS_ LIST_ UTILITIES
USER PROCESS SPACE
COMMUNICATION LAYER
SERVER PROCESS SPACE
ICAIS_ IO_ CONTROL
ICAIS_ IO_ EXCEPTIONS
ICAIS_ TEXT_IO
DICTIONARY_ MANAGER
ADA_IO
ADDITIONAL_ IO
OS I/O INTERFACES

AD-A207 521 KAPSE INTERFACE TEAM PUBLIC REPORT VOLUME 6(U) NAVAL 6/6
OCEAN SYSTEMS CENTER SAN DIEGO CA D L HAYWARD MAR 89
NOSC/TD-552-VOL-6

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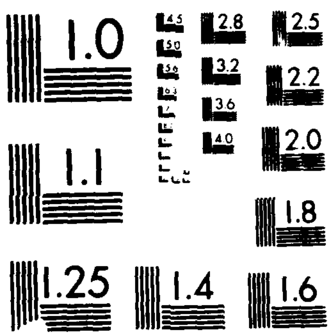
1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

Design Extended CAIS Subset

Current Emphasis:

- Access Control
- Concurrency Control

Experiment / Tool Build

In our future plans

Based on PA-APSE tool prototyping

DRAFT

On DoD Standards for Computing System Programming and Run-Time Support Environments

by

Edgar H. Sibley and Ann E. Reedy

Abstract

There are some problems that arise in specifying any computing system standards. These are found whether we are talking about governmental, national or international standards. Ultimately, the problems and their solutions are matters of acceptance and compliance, and part of this is a matter of policy and control ... be it at the local or global level. This paper examines the problems and solutions and asks the questions:

1. Are we, the KITIA, doing anything of value for DoD?

2. If we are, what is it?

1. Introduction

The first question that should be asked is:

What is a standard?

Unfortunately, there is a large range of answers, depending on the area and participants. In order to make some progress we shall therefore talk about "hard standards" and "soft standards" though (as will be seen later) we have other terms that have been applied.

2. "Hard" Standards

A "hard standard" is defined here as nationally legal required or otherwise rigidly enforced standard; typical examples are the Meter, Kilogram, Pound, Foot, Second, Degree Celsius, Ampere, and Volt. It is interesting to note that these do not include the Watt or Horse Power because they can be derived from the others.

Such hard standards are enforced (almost worldwide) by legal process. First there must be a Weights and Measures body (a Bureau of Standards) that has the sole right of defining the means of deriving and maintaining the standard. Then there is a body of people who legally check public compliance (possibly a Bureau of Weights and Measures). This body is responsible first for maintaining a set of "secondary standards." These must be

certified to be exact copies -- within acceptably small limits -- and regularly rechecked and recertified against the standard. The body then uses thes secondary standards to certify first class standard measuring devices (such as those used in machine shop standards rooms) and also for giving out certificates that show a certain scale or measure does match the secondary standard within reasonable limits. At this point, secondary standards may be produced for derived units (such as the Watt, Calorie and Joule), since they are useful for comparing other devices for compliance.

The other prime function of this body is to check complaints, or make spot checks, to ensure, for example, that the butcher's scales or gas station's pump is not short-changing the customers.

3. "Soft Standards"

Most of the other "Standards" in use today are soft -- in the sense that there are only local "rules" that make the users comply with them. Indeed there is a term that has been adopted for many of these: "industry voluntary standards." Many of them only exist because it is convenient to the participants; examples are nut and bolt sizes, photo film speeds and sizes, and pipe connections. The latter started in the USA when a major fire in Baltimore destroyed about a square mile of city though there were pumpers from as far North as New England (with most standing idle due to lack of ability to connect to the hydrants!). In wartime (e.g., the Korean War) there have been container standards, but these mostly lapsed due to lack of incentive (supplies increased and the Government relaxed its regulations).

The lack of Governmental or other enforcement mechanisms is generally the problem. For many good and bad reasons, variations arise locally. Some of these reasons are:

1. Academics feel that restriction to a standard will slow or stifle research in the area. The rallyiong cry is: "It's too soon to standardise."

[Please note that if we wait until a component is not moving or changing to standardise it, it has probably become useless or outmoded. An interim standard is reasonable -- see how the photo film standards have evolved]

2. Industry often feels that their competitive advantage with a current product is lost by imposition of a new standard (that overlaps their product).

[This has undoubtedly helped to hold up many good ideas in the past.]

3. Industry "adopts" the standard, but there are too many loopholes that allow the implementation to be sloppy or diverging from standard in places. The law is not enforced generally by the Government, and thus these "soft standard"

requirements may be disregarded with the only redress a civil suit (with costs that deter all but the wealthiest organizations).

4. A Laissez Faire attitude on the part of the enforcers. In this case, the rules may say: "Use a Standard" but monitoring for compliance is not rewarding or is too time consuming or expensive, etc. Unfortunately, also, the enforcing agent is often not fully conversant with the standard requirements and willing to allow divergence. The powerful player (a high corporate executive or Governmental Secretarial Staff member) believes there is a valid reason for allowing divergence.

Thus the soft standard can be seen as lacking the two parts needed in the hard standards case:

1. A body that truly certifies the standard and knows how to ensure that any "secondary standard" is in compliance within a specified tolerance.

[This testing must be tight enough to be meaningful -- e.g., a meter rule that is within 20% of standard is not very useful, yet there are many so-called "implementer defined" options in so-called standard computer language specifications.]

2. Another body that has legal and/or other control methods (such as sanctions) against non-compliers.

[This body must have almost absolute power -- and the realization of this by its detractors is normally a precursor to its death knoll]

In between, there are a large number of options that run the gamut from hard controls to none. The DoD probably is towards the soft-end in computer software production and run-time systems: there are few standards, they are subverted easily (or so it seems to the external observer, judging by the large number of variations from standard allowed), and there is certainly no tightness in the testing for standards, though there are attempts to do so by NBS and GSA, and through them by some service units.

4. Standards for Programming and Run-Time Support Environments

Before embarking on the questions of policy and economics, it is valuable to ask what are the real issues to be addressed when looking at standards for computing systems with special emphasis on programming and run-time support environments. There appear to be a few issues that have been discussed at length in KIT/IA meetings and are as yet only partially resolved. These issues seem, primarily, to devolve on a need for long time naming continuity and, in general, software configuration management. These issues will be used as examples for purposes of the following discussion.

The first issue is that of providing "Unique Names" across geographic and time boundaries. The term "unique name" (UN) has been used to define an immutable name for an object; e.g., a compiler should be uniquely identified by a UN, which neither changes nor is "recycled." Thus a UN is given to any important object and remains its name from then on, and if the object is deleted/removed, the UN will still identify the object, but an attempt to retrieve it will result in a statement that it is no longer available.

There are two possible problems:

1. Is any sort of change allowed to an object without its UN changing?

[Normally, the contents of the object are allowed to be altered, but this could mean that it is no longer even similar to its previous "parent" object. Certainly, it seems reasonable to allow the object to be a program named "X" and to allow it to be debugged without changing its name for each error detected. This would suggest the unique name was really a run-time UN, which could be said to remain constant during programming and debugging. However, if the UN were for a data object, the effect of a change in any one of its values would be a new "version" of the object, and this could be important enough to be considered a new "object" though the normal way of dealing with this is to consider the data object to be "time and date stamped" with an audit trail to allow the previous object to be reconstructed (roll out) if needed.]

2. How are UN related for the same (but changed) object?

[As suggested above, there is a method normally in use for previous data object reconstruction -- the roll out from an audit trail, however, the data in a traditional database must not be called by physical location, but by "name pointers" or indexes or "logical" keys -- these might be considered the UN for data. On the other hand, the only "audit trail" for programs is normally provided by the configuration management system (CMS). In fact, the idea of version in a CMS is another way of looking at the unique name; i.e., the UN is equivalent to a user name concatenated with the version number (or equivalent).]

What has been suggested above about a UN for both program and data could also hold for control structures.

5. Centralization and Decentralization Issues

The really tough problems of unique names of any of the types of objects occurs when they are (in some way or other) decentralized. The traditional hard standards are normally kept in one place, though it is not unreasonable to distribute them geographically. The controls are then distributed by using secondary (and less accurate) standards at the certification and complaint checking offices. It is therefore important to realize that:

There is only one true "standard" for any object.

Now consider the following scenario:

SCENARIO Part 1:

A compiler in Syracuse, with the UN of Ada-56, is to be used by DoD contractor ABC. For all sorts of reasons, the contractor now makes a copy of it.

First QUESTION Set:

1. Should the contractor be allowed to make the copy or just to use the compiler remotely?
2. If OK to copy,
   - Is the UN the same? and
   - Is there a central authority that knows this/or
   - Is there a note with the Ada-56 that says it has been copied by ABC?
3. If not OK to copy,
   - Does the compiler CMS(configuration management system) keep track of all programs compiled by it?

SCENARIO Part 2:

The ABC contractor now needs to alter the compiler.

Second QUESTION Set:

4. Is ABC allowed to do so?
5. If yes,
   - Is the UN changed?
     - If it is, who controls this, and how?
     - If not, we now have two copies with the same UN but different!
6. If no,
   - What is the mechanism for stopping it?
   - How can the ABC contractor get the change made?
   - How are other users who compiled programs informed of the change? (see Question 3)

SCENARIO Part 3:

The Syracuse group now need to alter the compiler for their own reasons; i.e., independently of the part 2 scenario.

Third QUESTION Set:

7. Under what conditions will the UN change?

SCENARIO Part 4 on:

Repeat the whole of the above for a database. Only the outline is given:

A database in Syracuse, with the UN of Per-67, is to be used by DoD contractor ABC. The contractor now makes a copy of it. The ABC contractor now needs to alter the data. The Syracuse group now need to alter the database for their own reasons; i.e., independently.

Fourth QUESTION Set:

8. Should the contractor be allowed to make the copy or just to use the data remotely?

9. If OK to copy,
   Is the UN the same? and
   Is there a central authority that knows this/or
   Is there a note with the Per-67 that says it has been copied by ABC?

10. If not OK to copy,
    Does the system keep track of all users and their authorization plus any triggers that are to inform them of any important changes?

11. Is ABC allowed to alter data?
    Is it at the copy or at the original (depending on Question 8)?

12. If yes,
    Is the UN changed/ which one?
    If it is, who controls this, and how?
    If not, is there to be an automatic update to the original database?

13. If no,
    What is the mechanism for stopping it?
    How can the ABC contractor get the change made?
    How are other users informed of the change? (see Question 10)

14. Under what conditions will the UN change when the Syracuse group change data?

Obviously, the answer to much of the above question set is a matter of policy and method of control. The answers must reflect our beliefs in the intent of the organization (here DoD) and the consent of the participants to comply with the "laws."

The traditional structure of three level management in providing policy (goals) and control (operatiioonal) is usually as given by the diagram:

```
                       Policy                     Top Management
                         |
                 Resource Allocation          Middle Management
                         |
              Organizational Controls         Lower Management
```

The use of the concept of distribution of authority (usually termed "delegation of authority") gives rise to one possible solution:

```
                 Central Control
                        |
                        |
                Regional Control
                        |
                        |
                   Local Control
                        |
                        |
              more levels (as needed)
```

This could allow a "Dictionary/Configuration Management" system solution as follows:

```
Central Cont          Central Dicty          Central Progs
    |                     |                      |
    |                     |                      |
Regional Cont         Regional Dicty        Regional Progs
    |                     |                      |
    |                     |                      |
Local Cont            Local Dicty            Local Progs
    |                     |                      |
    |                     |                      |

 CONTROL            DICTIONARY/CMS        PROGRAM LIBRARIES
```

It is academically interesting to consider the following possible structuring:

1. Programs and Procedur (at least in the Ada world) have "generic" and "specific instances" that are related "hierarchically."

2. Data Names and Structures (in the DBMS database management world) have "schema" and "data" that are related

"hierarchically."

3. Control and structures (in modern programming systems) have policy, control, tasks, tools, etc that appear to be related, in part, "hierarchically."

The relationships between these three are indicated in the next figure, which does not suggest a hierarchy that bears any resemblance to that of the distributed control/dictionary/library above.

```
General Systems and Programs
      |     •
      |      •
      |       Data Structure
      |      /
      |     /
    Policy
```

6. Some Alternative Distributed Solutions

There have been several ways of keeping track of data and programs in a distributed system; some are:

1. Central Control with a Centralized directory/dictionary

   Just know all locations of named objects and either not allow anyone other than central administration to make changes or else control and monitor update.

2. Central and distributed directories/dictionary

   Some controls are needed to decide whose or what changes are allowed. A method of passing information up and down the system (from central to local and back) is essential.

3. Broadcast Updates to distributed directories/dictionary

   In this, the control is always at the local port, but all communication will be via a "Now hear this ..." type of message, and it is the responsibility of each node to react and to update correctly when informed. (The responsibility of the central node is to be sure the message of change is received, and then it terminates all responsibility.) This is a form of "Delegation of Authority."

7. Some Comments on the Policy Aspects

Is there any really high level DoD policy that can be discerned from the Ada and Software Initiatives? It sems that the only sure one is:

We must reduce the cost of software.

But if this is the case, we must ask:

What does this entail?

The paper so far has tried to raise questions that seem to be central to the theme of software production. But they primarily nucleate on one group of factors:

Who is in charge? -- Who sets policy? -- Will it be enforced?

The whole question of standards is moot if only a small part of the services are going to use (and enforce use) of them. It seems unlikely that there is enough political power (or true intent) to enforce the policies needed to gain through the use of Ada and STI. If we cannot be sure that there is a policy for hard standards in computing, we are unlikely to reach more than a few percentage points of the predicted (possible) cost reductions. If we are not going to control the mixture of production and run time systems, we have again failed.

The ultimate ability of the DoD to reduce the cost of software devolves on its seriousness. To achieve reductions, we must:

1. Have a good rationale for policy on software production and run-time standards. This must be agreed at a sufficiently high level that it cannot be transcended by anyone.

   [It is extremely unlikely that this is possible]

2. Implement the policy through a mechanism for control based on one of the ideas presented here (the specific method is irrelevant, but a good control mechanism is essential).

   [Otherwise we can only make partial gains, and the chance of the current state of anarchy will continue]

The final question is to ourselves:

Are we playing any valuable part to DoD if we only answer the easy questions and ignore the "real" problems -- i.e., the ones that will ultimately show whether the Ada and STI effort was useful or just another "computer science promise."

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